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A supplementary study on *Protoblechnum* Lesquereux from China

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ABSTRACT

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The frond structure of *Protoblechnum* and the other similar plants is examined. These plants are like the neuropterids of the Late Palaeozoic Era, with forked or unforked rachides, whose fronds are simple pinnate or pinnately compound leaf and unequally or equally pinnate fronds. Based on the new materials of the bipinnatifid fronds of *Protoblechnum contractum* (Gu & Zhi) from Henan in China, it may be seen that other species of *Protoblechnum* besides *Protoblechnum wongii* Halle may also be bipinnatifid fronds. The discovery provides important materials for making a clear distinction among *Protoblechnum* and similar plants.

Key-words—China, Shihhotze Formation, Plant megafossils, *Protoblechnum, Compsopteris.*

सारांश

चीन से प्राप्त *प्रोटोब्लेक्नम* लेस्क्वीरियक्स का एक सम्पूरक अध्ययन

सन बेनियान एवं शेन गुआंग्लाँग

प्रोटोब्लेक्नम तथा अन्य मिलते-जुलते पौधों की प्रपर्ण संरचना का परीक्षण किया गया। ये पौधे अन्तिम पेलियोजोइक कल्प के द्विशाखित अथवा अशाखित अक्ष युक्त न्यूरॉप्टेरिडों की भांति के हैं, जिनके प्रपर्ण सरल, पिच्छाकार अथवा पिच्छकित संयुक्त पत्तियां एवं असमरूप अथवा समरूप पिच्छाकार प्रपर्ण हैं। चीन के हेनान प्रान्त से प्राप्त *प्रोटोब्लेक्नम कॉन्ट्रेक्टम* (ग एवं झी) के द्विपिच्छकित प्रपर्णों से नवीनतम प्राप्त पदार्थों के आधार पर यह देखा जा सकता है कि *प्रोटोब्लेक्नम वोंगाई* हाले के अतिरिक्त *प्रोटोब्लेक्नम* की अन्य प्रजातियाँ भी द्विशाखित प्रपर्ण युक्त हैं। इस अनुसन्धान से *प्रोटोब्लेक्नम* एवं अन्य मिलते-जुलते पौधों में स्पष्ट विभेद करने हेतु अत्यन्त महत्त्वपूर्ण सूचना प्राप्त हुयी हैं।

INTRODUCTION

A dispute exists since long over the relationship between *Protoblechnum* and other similar plants, such as, *Compsopteris, Glenopteris* and *Supaia* in Permian floras of China, but it has not been completely solved up to now. The difference of opinion as how to choose suitable generic name still exists because of obvious form variation in the fossils collected by researchers.

BACKGROUND OF *PROTOBLECHNUM*

Halle (1927) while studying the fossil plants from the Late Palaeozoic strata in Shanxi, China placed a few simple pinnate fronds from the Shihhotze Formation in the genus *Protoblechnum* and named them *Protoblechnum wongii* Halle. Lesquereux (1880) had erected the genus *Protoblechnum* for specimens of *Alethopteris holdeni* described by Andrews (1875), which are simple pinnate fronds with unforked ra-

chides. Halle (1927) while discussing the distinction between *Protoblechnum* and other relative fossils pointed out that it would also be necessary to place forked *Danaeopsis hughesi* Feistmantel from the Indian Triassic under the genus *Protoblechnum*. Thus it can be seen that he did not think forked or unforked fronds as an important condition to distinguish genera. Yabe and Oishi (1928a, b) accepted Halle's opinion and put under the genus *Protoblechnum* a few similar specimens from Permian strata of Shandong Province that were also simple pinnate fronds and did not have forked rachides.

White (1929), on the other hand, while researching the fossil plants collected from the Permian Hermit shale of Grand Canyon, America did not agree with views of Halle and Yabe and Oishi. He expressed the opinion that he would prefer to refer the Chinese species, which had simple pinnate fronds and unforked rachis, to the genus *Glenopteris* Sellards (1900), and the Indian species *Danaeopsis hughesi* Feistmantel, whose rachis is forked, to his new genus *Supaia*. Zalessky (1934, 1935) also found some specimens in the Permian of Russia similar to Chinese *Protoblechnum*. He did not approve of using the genus *Protoblechnum*, either. He grouped some specimens with forked rachides into *Supaia* White and the others showing simple pinnate fronds and without forked rachides to his new genus *Compsopteris*.

After the People's Republic of China was founded, the fossil plants of this type have often been recorded in the Permian strata of China and their form structure is also different. Sze (1955) first reported a forked frond from Permian System of southeast Shanxi. He did not adopt the name *Supaia* White and supported Halle's view and used the name *Protoblechnum*, which obtained support of many scholars such as Zhou Zhiyan and Li Xingxue. Townrow (1957) pointed out that the original *Protoblechnum* and *Supaia* of forked rachides from China and America, respectively should be placed in the genus *Dicroidium* with Indian *Danaeopsis hughesi*.

PROTOBLECHNUM AND *COMPSOPTERIS* FROM CHINA

Gu & Zhi (in Li Xingxue *et al.*, 1974) considered that Chinese *Protoblechnum* was quite similar to *Compsopteris*, and thus the former should be transferred to the latter. According to their opinion, *Protoblechnum wongii* Halle including *Protoblechnum hallei* Yabe & Oishi described in China should be merged as *Compsopteris wongii* (Halle) Zalessky. They also set up two new species, that is, *Compsopteris imparis* Gu & Zhi and *Compsopteris contracta* Gu & Zhi. The above mentioned three fossils were all simple pinnate fronds and the rachides forked once or not at all. Many scholars agreed with the opinion and the name *Compsopteris* has been gradually accepted in China since then (Feng Shaonan *et al.*, 1977; Chen Ye & Duan Shuyin, 1978; Zhang Jihui, 1978; Yang Guanxiu & Chen Feng, 1979; Zhao Xiugu *et al.*, 1980; Chen Lizhu, 1982; Wang Guoping *et al.*, 1986; Li Peijuan & He Yuanliang, 1986; Yang Guangrong *et al.*, 1986; Huang Lianmeng *et al.*, 1987; Zhu Tong, 1990; Kong Xianzheng *et al.*, 1990).

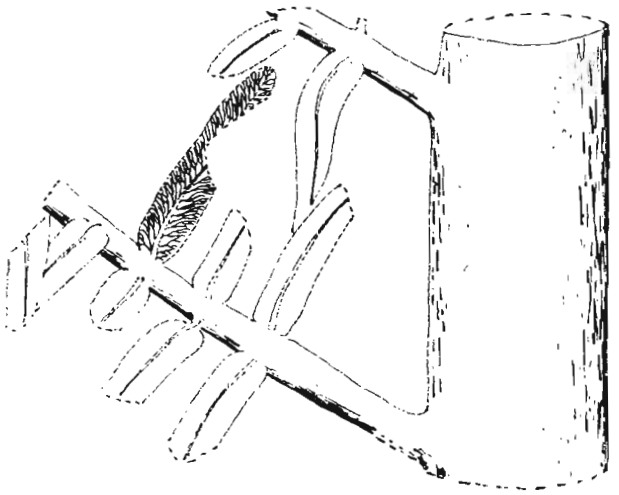
In 1977, Huang Benhong found a great number of fossils of this type from Xiao Xin'an Mountains in Northeast China, too. He considered that the forked or unforked nature of rachis should be an important basis for generic distinction. He, therefore, put the forked fronds into *Supaia* and the unforked specimens into *Compsopteris*. Shen Guanglong (1995), however, included Chinese specimens of *Protoblechnum wongii* Halle with forked rachides in *Supaia* and for those with unforked rachides and simple pinnate he still reserved the name *Protoblechnum* as a form genus. *Compsopteris* has not been used until it has been confirmed as the same kind of plants as in the Angara flora on the basis of cuticular studies.

Liu Lujun (1989) discovered a lot of fossil plants from southeast Shanxi, among which were some bipinnatifid fronds. After reading relative references, he expressed the views to use *Protoblechnum* in the Cathaysian flora and limit *Compsopteris* in the Angaran flora. In conformity with his view, it is clearly seen that the formerly described specimens of *Protoblechnum* type from China may be placed in the genus *Protoblechnum* no matter simple pinnae or bipinnae they are; no matter forked or unforked rachides they have.

Wang (1996) has recently pointed out that *Supaia* which had simple pinnate fronds and forked rachis might have evolved from *Protoblechnum wongii* Halle which had bipinnatifid fronds and unforked rachis. It is a result of palaeoclimatic changes, which can be well explained by Asama's Growth Retardation Theory (1960). According to Wang's study, there are two types of the pinnule base in *Supaia* from the Upper Shihhotze Formation in Shanxi, China. One has a decurrent base as in *Protoblechnum wongii* and the other has a contracted base like *Protoblechnum contractum*. Among published records from China, the specimens of *Protoblechnum contractum* are all simple pinnate fronds, contracted bases of pinnule and unforked rachides. It is of vital significance to get a specimen of bipinnatifid fronds of *Protoblechnum contractum* from Permian strata in China if Wang's guess is correct about the origin of *Supaia* from the Upper Shihhotze Formation of Shanxi, China. Furthermore, it may show that both *Protoblechnum wongii* and *Protoblechnum contractum*, which are all bipinnatifid fronds but whose bases of pinnules are different (one decurrent, the other contracted), possibly represent two directions of the evolution from *Protoblechnum* to *Supaia*.

Kapoor *et al.* (1992) considered that *Kashmiropteris meyenii* Kapoor, a possible cycadalean leaf from the Early Permian Mamal Formation in the Kashmir Himalaya, showed a certain resemblance to *Protoblechnum* Lesquereux 1880 and *Compsopteris* Zalessky 1934, but leaves of both these genera

Figure 1—*Protoblechnum contractum* (Gu & Zhi) emend. x1.



Text-figure 1 :—*Protoblechnum contractum* (Gu & Zhi) emend. x 1

differ from that of *Kashmiropteris meyenii* in the venation pattern of the pinnae. It is very interesting that *Kashmiropteris meyenii* has also two type bases of pinnae or pinnules, one contracted (Kapoor *et al.*, p. 143, pl.1, figs 1-3), the other decurrent (p. 145, pl. 2, figs 1-2).

DISCUSSION

According to present materials, the rachides of both *Protoblechnum* and *Glenopteris* in North America are unforked and their leaves are simple pinnate fronds. They are almost showing no difference in other shape features and may be merged. The former should be kept and used because of its priority. As to the similar fossils with a forked rachis, the genus *Supaia* erected by White can be applied because the forked or unforked rachides is an important basis for generic segregation. The leaf of *Compsopteris* is simple frond. Although the appearance of the genus is the same as that of *Protoblechnum*, the cuticular structure of *Compsopteris* ascertained by Meyen & Migdissova (1969) is different from that of *Protoblechnum*. And the former with an unforked rachis, which differs from the *Supaia*, ought to be reserved and limited in the Angara area. As for Indian species *Danaeopsis hughesi* with a forked rachis, it has been transferred to another genus because the reproductive organ and the cuticular structure of *Danaeopsis hughesi* have been clearly studied. The genus has nothing to do with *Supaia* and is also one of local plant members in the Angara area.

It may be seen from the foregoing review that the frond structure of *Protoblechnum* and the other similar taxa is rather complex. Based on accumulated materials, these plants may be like neuropterids of the Late Palaeozoic Era, whose rachides were forked or unforked, fronds were simple pinnate or pinnately compound leaf and unequally or equally pinnate fronds. All of these will depend on further field work and study so that the kind of plant can be identified reasonably. Therefore, it is very important that a new specimen which can reveal detailed structure of the plant is discovered.

NEW MATERIALS

In the Summer of 1994, one of the authors (Sun Bainian) collected many good specimens of *Protoblechnum* from the Upper Shihhotze Formation at Dengfeng Coalfield in Henan, among which there are several specimens of bipinnatifid fronds. The authors of present paper think that these bipinnae should be *Protoblechnum contractum* (Gu & Zhi). This discovery not only indicates that other species of *Protoblechnum* besides *Protoblechnum wongii* Halle can be bipinnatifid fronds but also provides important materials for making a deep dis-

tinction between *Protoblechnum* and similar plants. In accordance with the new materials from Henan, an emended diagnosis of *Protoblechnum contractum* (Gu & Zhi) is given.

PROTOBLECHNUM CONTRACTUM

(Gu & Zhi) Sun Keqin emend

(Fig. 1; Text-figure 1)

1974 *Compsopteris contracta*, Gu & Zhi (in Li Xingxue *et al.*), p.115, pl. 82, figs 4-6; pl. 83, figs 1-3, Text-figure 79.
1977 *Compsopteris contracta*, Feng Shaonan *et al.*; p. 659, pl. 245, figs 6-7.
1978 *Compsopteris contracta*, Chen Ye & Duan Shuyin, p. 465, pl. 152, figs 2-3.
1978 *Compsopteris contracta*, Zhang Jihui, p. 475, pl. 159, figs 2-3.
1979 *Compsopteris contracta*, Yang Guanxiu & Chen Feng, p. 126, pl. 35, figs 7-8.
1980 *Compsopteris contracta*, Zhao Xiugu *et al.*, p. 82.
1982 *Compsopteris contracta*, Chen Lizhu, p. 517, pl. 331, fig. 8.
1982 *Compsopteris contracta*, Wang Guoping *et al.*, p. 366, pl. 153, fig. 10.
1986 *Compsopteris contracta*, Yang Guangrong *et al.*, p. 11, 32, pl. 18, fig. 10.
1987 *Compsopteris contracta*, Huang Lianmeng *et al.*, p. 44, pl. 22, fig. 5; pl. 23, fig. 1-2.
1990 *Compsopteris contracta*, Zhu Tong, p. 96, pl. 3, 6, pp. 34, figs 1-3.
1991 *Protoblechnum contractum*, Sun Keqin, p. 40-41, pl.13, fig. 2.
1991 *Protoblechnum contractum*, Yang Jinyao, p. 41, table 2-9.
1995 *Protoblechnum contractum*, Shen Guanglong, p. 101, 108, 130, 139.
1996 *Protoblechnum contractum*, He Xilin, Liang Dunshi & Shen Shuzhong, p. 59, pl. 45, fig. 4.
1996 *Compsopteris contracta*, Kong Xianzheng *et al.*, p. 188-189, pl. 13, fig. 1,1a.

Description—Frond very large, bipinnate, rachis thick, attaining 2.8 cm in width, obviously thin drops on the surface of rachis; ultimate pinnae 8 cm in width and unknown in length; ultimate rachis thick, 5-7 mm broad; pinnule 9 mm wide, scattered in arrangement, long linear or strap-shaped, margin entire, base contracted; midrib strong, 1-1.5 mm in width, nearly reaching to the apex, at a right angle extended from the rachis; lateral veins fine and close, curving outside at a small angle from the midrib, dichotomizing twice or thrice, 20-25 veins per cm on the margin.

Comparison—The present specimen with unforked rachis, bipinnate frond, shape and veins of ultimate pinnae is like *Protoblechnum wongii* Halle, but the distinction lies in the obviously contracted base of pinnules in the former.

Locality and Horizon—Dengfeng, Henan; Upper Shihhotze Formation.

Specimen No. and Repository—PB93174; Palaeontologic laboratory of Geological Department, Lanzhou University.

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REFERENCES

Andrews EB 1875. Description of fossil plants from the Coal Measures of Ohio. Rep. geol. Surv. Ohio 2, (2) : 420.

Asama K 1960. Evolution of the leaf forms through the ages explained by successive retardation, Sci. Rep. Tokyo Univ., 2nd ser. (Geol.), Spec. Vol. 4 : 252-280.

Chen Lizhu 1982. Fossil plant. *In* : Bureau of Geology of Hunan Province (Editor)—*Fossil Plate of Hunan*. Geol. Press, Beijing : 517 (in Chinese).

Chen Ye & Duan Shuyin 1978. Fossil Plant. *In*: Southwest Inst. of Geol. Sci. (Editor)—*Fossil Plate of Southwest China (II), Part of Sichuan province, Beijing*, Geol. Press, 465 (in Chinese).

Feistmantel O 1882. Fossil flora of the Gondwana System. The fossil flora of the South Rewa Gondwana Basin. Mem. geol. Surv. India, Palaeont. indica, ser. 12, 4(1) : 1-52.

Feng Shaonan, Chen Gongxin, Xi Yunhong & Zhang Caifan 1977. Fossil Plant. *In*: Hubei Inst. of Geol. Sci. (Editor)— *Fossil Plate of Central and South China (II), Geol. Press, Beijing* : 659-660 (in Chinese).

Gu & Zhi (in Li Xingxue, Zhou Zhiyan, Deng Longhua, Xu Ren & Zhu Jianan) 1974. Fossil plants from China. 1 : Palaeozoic plants of China. Inst. Geol. and Palaeont. Inst. Bot. Science Press, Beijing : 114-115.

Halle TG 1927. Paleozoic plants from Central Shansi. Palaeont. Sinica, ser. A, 2, Fac.1 : 131-138.

He Xilin, Liang Dunshi & Shen Shuzhong 1996. Research on the Permian flora from Jiangxi Province, China. China Univ. of Mining & Technol. Press, Xuzhou : 59 (in Chinese with English Abstract).

Huang Benhong 1977. Permian flora from the southeastern part of the Xiao Xingan Lin, NE China. Geol Press, Beijing (in Chinese with English Abstract).

Huang Lianmeng, Huang Yuning, Mei Meitang & Li Shengsheng 1989. The Early Permian coal-bearing strata and flora from Southwest Fujian province, South China. Coal Industry Press, Beijing (in Chinese with English Abstract).

Kapoor HM, Bajpai U & Maheshwari HK 1992. *Kashmiropteris meyenii* Kapoor : A possible cycadalean leaf from the Early Permian Mamal Formation in the Kashmir Himalaya. Palaeobotanist 39(2) : 141-148.

Kong Xianzheng, Xu Huilong, Li Renlan & Liu Lujun 1996. The Late Palaeozoic coal-bearing strata and fossils from Shanxi Province, North China. Science & Technical Press of Shanxi, Taiyuan (in Chinese with English Abstract).

Lesquereux L 1880. Description of the coal flora of the Carboniferous Formation in Pennsylvania and throughout the United States. Second Geological Survey Pennsylvania, Rep. of Progress. 1 : 188.

Liu Lujun 1989. Discovery of bipinnatifid fronds of *Protoblechnum wongii* Halle with discussion. Acta Palaeont sinica. 28(4) . 447-454.

Li Peijuan & He Yuanliang 1986. Late Triassic plants from Mt Burhan Budai, Qinghai. *In*: Qinghai Inst. of Geol. Sci. & Nanjing Inst. Geol. and Palaeont., Academia Sinica (Editor)—*Carboniferous*

and Triassic strata and fossils from south slope of Mt Burhan Budai, Qinghai. Anhui Sci. & Technology Press, Hefei : 275-293 (in Chinese with English Abstract).

Meyen SV & Migdissova AV 1969. Epidermal investigation of Angara *Callipteris* and *Compsopteris*. In : Pteridosperms from Upper Palaeozoic and Mesozoic (in Russian). Academy of Sciences of U.S.S.R., Moscow, pp. 59-84.

Sellards EH 1900. A new genus of ferns from the Permian of Kansas. Kansas Univ. Quart. 9 : 179-189.

Shen Guanglong 1995. Permian floras. *In*: Li Xingxue (Editor)—*Chinese floras through geological ages*. Guangdong Sci. & Technology Press, Guangzhou : 94-173.

Sun Keqin 1991. Late Carboniferous and early Permian flora, palaeoecology and sedimentary environment in the Zibo area, Shandong. Jilin Univ. Press, Changchun. : 41-42.

Sze HC 1955. On a forked frond of *Protoblechnum wongii* Halle. Acta Palaeont. Sinica 3(1) : 11-24.

Sze HC & Li Xingxue 1963. Fossil plants from China. II. Mesozoic fossil plants of China. Science Press, Beijing : 140-142.

Townrow JA 1957. On *Dicroidium*, probably a pteridospermous leaf and other leaves now removed from this genus. Trans. geol. Soc. S. Afr. 60 : 19-33.

Wang Guoping, Lan Shanxian, Li Hanming, Li Xingxue, Wu Xiuyuan, Mo Zhuangguan, Chen Qisi & Cai Chongyang 1982. Plant Kingdom. *In*: Nanjing Inst. Geol. and Mineral Resources (Editor)—*Fossil Plate of East China (II), Geol. Press, Beijing* : 366-378 (in Chinese).

Wang Ziqiang 1996. Past global floristic changes, the Permian great Eurasian floral interchange. Palaeontology 39(1) : 189-217.

White D 1929. Flora of the hermit shale, Grand Canyon, Arizona. Carnegie Inst. Washington, Publ. (405) : 54-78.

Yabe H & Oishi S 1928a. A new species of *Protoblechnum* from the Heishan Coalfield, Shantung. Jap. J. Geol. Geogr. 6 : 15-17.

Yabe H & Oishi S 1928b. A note on *Protoblechnum wongii* Halle Jap. J. Geol. Geogr. 6 : 61-62.

Yang Guangrong, Zhang Yucheng & Huang Yu'an 1986. Division of Upper Permian and coal-bearing characters in Southern Sichuan. People's Press of Chongqin, Chongqin (in Chinese with English Abstract).

Yang Guanxiu & Chen Feng 1979. Fossil Plants. *In*: Hou Hongfei, Zhan Lipei & Chen Bingwei (Editor)—*The Permian coal-bearing strata and fossils from Guangdong province, South China. Geol. Press, Beijing* : 104-144 (in Chinese with English Abstract).

Yang Jinyao 1991. Strata. *In*: Guo Xinian (Editor)—The Late Palaeozoic coal-accumulating laws in Henan Province. Geol. Univ. Press of China, Wuhan : 39-40 (in Chinese with English Abstract).

Zalessky MD 1934. Observations sur les vegetaux, Permien du bassin de la Petchora I, Acad. Sci. URSS Bull. (2-3) : 241-290.

Zalessky MD & Tchirkova HTh 1935. Observations sur quelques vegetaux fossiles du terrain Permien du bassin de Kousenetzk. Acad. Sci. URSS Bull. Math. Natur Sci : 1091-1116.

Zhang Jihui 1978. Fossil Plant. *In* : Guizhou Team of strata and fossils (Editor)—*Fossil Plate of Southwest China (II), Part of Guizhou province, Geol. Press, Beijing* : 475-476 (in Chinese).

Zhao Xiugu, Mo Zhuangguan, Zhang Shanzheng & Yao Zhaoqi 1980. Late Permian flora from west Guizhou and east Yunnan. *In* : Nanjing Inst. of Geol. and Palaeont., Academia Sinica (Editor)—*Late Permian coal-bearing strata and fossils from west Guizhou and east Yunnan. Science Press, Beijing* : 70-99.

Zhao Xiugu, Liu Lujun & Hou Jihui 1987. Carboniferous-Permian flora of coal-bearing strata from southeast Shanxi. *In* : the 114th Team of Shanxi Company of Coal Geology & Nanjing Institute of Geology and Paleontology, Academia Sinica (Editor)—Late Palaeozoic coal-bearing strata and fossils from southeast Shanxi, Nanjing Univ. Press, Nanjing : 61-137.

Zhou Zhiyan, Zhang Shanzheng & Zhang Lujin 1955. An additional specimen of forked frond of *Protoblechnum wongii* Halle. Acta Palaeont. Sinica, 3 (3) : 167-171.

Zhu Tong 1990. The Permian coal-bearing strata and fossils from Fujian province, South China. Geol. Press, Beijing (in Chinese with English Abstract).