
Study on the morphology of *Nilssoniopteris huolinbensis* Duan et Chen sp. nov.

Duan Shuying & Chen Ye

Duan Shuying & Chen Ye 1996. Study on the morphology of *Nilssoniopteris huolinbensis*. *Palaeobotanist* 45 : 355-360.

The paper deals with the external form and the epidermal structures of *Nilssoniopteris huolinbensis* Duan et Chen. collected from the Early Cretaceous of the eastern part of Inner Mongolia. Rich Bennettitalean plants in the assemblage suggest the existence of warm and humid subtropical climate during the Early Cretaceous in the eastern part of Inner Mongolia.

Key-words—*Nilssoniopteris huolinbensis*, Morphology, Early Cretaceous, Inner Mongolia.

Shuying Duan & Ye Chen, Institute of Botany, Chinese Academy of Sciences, Xiangshan, Beijing 100 093, China.

सारांश

निल्सोनियाँटेरिस हुओलिनहेन्सिस दुआन व चैन नव जाति का आकारिकीय अध्ययन

दुआन शुइंग एवं चैन ये

आन्तरिक मंगोलिया के पूर्वी भाग में क्रीटेशस कालीन स्तरों से एकत्रित निल्सोनियाँटेरिस हुओलिनहेन्सिस दुआन व चैन की आकारिकीय एवं उपचर्मीय संरचना का अध्ययन किया गया है। इस समुच्चय में विद्यमान बैन्नेटाइटेली पौधों की अधिकता से इस क्षेत्र में प्रारम्भिक क्रीटेशस काल में गर्म एवं आर्द्र उपोष्णकटिबन्धीय जलवायु का होना इंगित होता है।

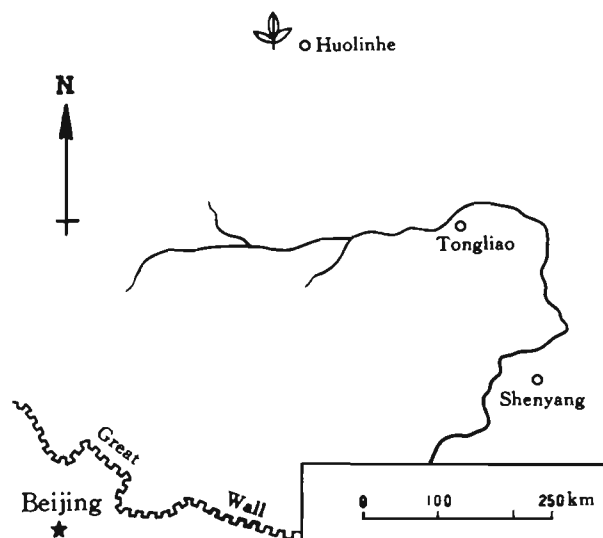
SEVERAL Late Mesozoic coal basins, e.g., the Hailaer Basin, Houlinhe Basin and Chifeng Basin, etc. situated in the eastern Inner Mongolia, are well-known in China. A number of fossil plants were collected and studied from these basins. The material described in this paper was collected by the authors from the Huolinhe coal mine situated in Zhelimu Meng (league, corresponding to a prefecture) nearby the Tongliao city, the eastern Inner Mongolia (Text-figure 1).

Huolinhe coal basin is about 60 km long and 9 km wide, situated along the north-west side of southern part of Daxinganling Ridge, stretched from northeast to southwest direction. The coal-bearing formation dips from southeast to northwest, with angle of less than 10 degrees. The oldest strata in this district are slightly metamorphosed rocks of the Car-

boniferous-Permian, but no outcrop was seen in the coal mine. The coal-bearing sediments are more than 1700 m thick, with numerous coal seams and intercalated dark or light grey sandstones and siltstones. The covering strata are sands and soils of the Quaternary Period.

This area is very rich in fossil plants. The flora consists of more than 40 species of different ferns and gymnosperms : Ginkgoales, Czekanowskiales, Coni-feropsida, Cycadales and Bennettiales. The important taxa are : *Selaginella* sp., *Equisetum burejense*, *Equisetum* sp., *Acanthopteris gothani*, *Coniopteris heeviana*, *C. setacea*, *C. ermolaevii* (Vassil.), *Coniopteris* sp., *Cladophlebis argutula*, *C. sp.*, *Dicksonia concinna*, *Asplenium dicksonianum*, *Nilssonia schauburgensis*, *Chiaohoella* sp., *Ctenis formosa*, *Pterophyllum burejense*, *Pterophyllum* sp., *Nilssoniopteris prynadae*, *N. didaoensis*, *N. huolinbensis* sp. nov., *Neozamites* sp., *Taeniopteris* sp., *Ginkgoites digitata*, *G. huttoni*, *G. obrustchewi*,

The project is supported by the National Natural Science Foundation of China and special support of Palaeontological and Palaeoanthropological investigation from Chinese Academy of Sciences.



Text-figure 1

Baiera sp., *Sphenobaiera wrinerius*, *S. pulchella*, *Eretmophyllum subtile*, *E. latum*, *Phoenicopsis angustifolia*, *Pityophyllum lindstroemi*, *Pityocladus yabei*, *Podozamites lanceolatus*, *Elatocladus* sp., *Schizolepis* sp., etc. The new species *Nilssoniopteris houlinbensis* was collected from the roof of No. 14 coal seam which also comprises various sized leaves. They belong to the same species because all of them have the same cuticular structures. This new species has been described in detail in this paper.

DESCRIPTION

Nilssoniopteris huolinbensis Duan et Chen sp. nov.

Pls 1-3

"Folia simplicia, *Taeniopteris*-typica; lamina longitudinalis varia, 1.4-4 cm lata, apice acutiuscula, basi attenuata, margine integra, axi mediana dorso 2-3 mm lata ventre 1 mm lata, nervis lateralibus parallelis, 18-20 per cm prope marginem laminae, cum axi mediana sub angulo 90 patentibus plerumque simplicibus interdum prope axin medianam dichotomis.

Parietes cellularum epidermidis undulati. Epidermis infera stigmatibus syndetocheilicis praedita, faciebus stomatiferis et faciebus nervalibus conspicuis, stigmatibus paucis sparsis directione irregularibus. Epidermis supera et axis mediana stig-

matibus carens. Epidermis infera et supera et axis mediana basibus pilorum praedita"

Leaf simple, *Taeniopteris*-type, margin entire, width of leaf 1.4-4 cm, length varying, more than 6 cm for the narrower leaves, more than 16 cm for the wider leaves, tapering towards base slightly, apex somewhat acute. Lamina attached to the upper side of midrib, showing wrinkles, 1 mm wide on the upper side and 2-3 mm wide on the lower side. Lateral veins parallel and almost at right angle to midrib, mostly simple, a few forked once near the midrib. Concentration of veins 18-20 per cm on the margins (Pl. 1, figs 1-5).

Cuticles well-preserved, moderately thick, the lower cuticle often complete with conspicuous stomatal bands 500-600 μm wide (350-400 μm wide in some leaves) and narrower nonstomatal bands (60-80 μm wide) along the veins. Stomata sparse in distribution, 29-39 per sq mm, scattered and irregularly oriented, mostly transverse, some longitudinally or oblique. Along the veins, the epidermal cells are regularly rectangular, 60-80 μm long, 20-30 μm wide, 2-3 rows without stomata but with a few trichome bases (Pl. 2, fig. 1). Between the veins, the epidermal cells are irregularly polygonal, 40-60 μm long, 20-40 μm wide, cell walls strongly sinuous with folds 6-8 μm apart, surface of cells flat, no papilla present. Trichome bases more or less consist of 2-4 cells, some very close to stomata (Pl. 2, fig. 3; Pl. 2, fig. 5). Size of stomata nearly equal in size, elliptic, 60-75 μm long, 35-50 μm wide, syndetocheilic, two subsidiary cells often asymmetric, their outer margin thick with coarse tooth-like projections. Guard cells sunken, stomatal aperture 35-50 μm long, the middle part of aperture usually covered by papilla of well cutinised subsidiary cells (Pl. 2, fig. 5; Pl. 3, figs 1-4). Surface of epidermal cells smooth, non-papillate. Trichome bases appearing in the bands between the veins and along the veins, small or large, comprising 1-4 cells of different shapes: round or elliptical (Pl. 1, fig. 10; Pl. 2, figs 8-9). Larger trichome bases are 50 x 110 μm , smaller ones 25 x 60 μm , diameter of round trichome bases 40-50 μm . The number of trichome bases is often less than those of the stomata (Pl. 2, fig. 1).

Upper cuticles are usually fragile, non-stomatiferous, the veinal bands are slightly distinguished from inter-veinal bands by narrower rectan-

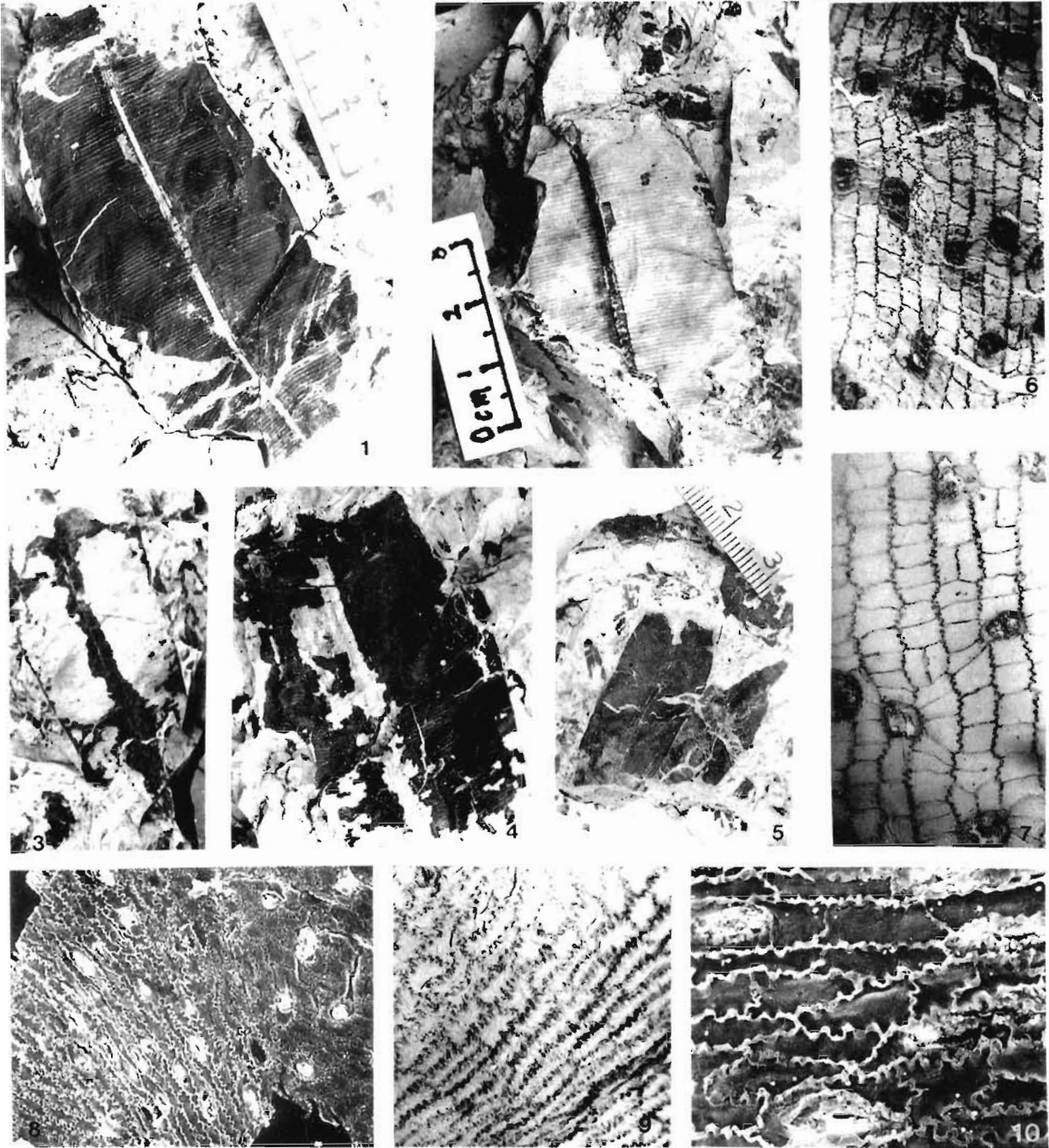


PLATE 1

Nilssonopteris huolinhensis sp. nov.

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|-------|--|--------|---|
| 1-5. | External form of leaves. x 1. | 63, 6. | Slide No. 8373 (1), 7. Slide No. 8372 (2). |
| 1. | Specimen No. 8370 (2), Holotype | 8. | SEM photograph showing stomata on the lower cuticle (right), trichome bases on the midrib (middle) and upper cuticle non-stomatiferous, left) x 90. Slide No. 8372. |
| 2. | Specimen No. 8371 (2) | 9. | Midrib and lower cuticle (right, showing three stomata) and upper cuticle (left) x 63. Specimen No. 8371. |
| 3. | Specimen No. 8371 (1). | 10. | SEM showing trichome bases on the midrib. x 150. Slide No. 8372. |
| 4. | Specimen No. 8370 (1). | | |
| 5. | Specimen No. 8373. | | |
| 6, 7. | Epidermal cells and trichome bases on the lower side of midrib x | | |

gular cells. Trichome bases are less than those on the lower cuticles, no papilla or other thickening (Pl. 1, figs 8, 9).

The cuticle of midrib thick showing nearly uniform rectangular cells with trichome bases (Pl. 1, figs 8, 9, 10), upper side of midrib narrower than lower one, the former being composed of 18-32 rows with a few trichome bases and the latter composed of 42-50 rows with more trichome bases (Pl. 1, figs 6, 7). Stomata absent, walls of cells strongly sinuous.

Holotype—Specimen no. 8370.

Paratype—specimen nos. 8371, 8372, 8373 and 8374.

Horizon & Age—Huoline coal basin, Early Cretaceous.

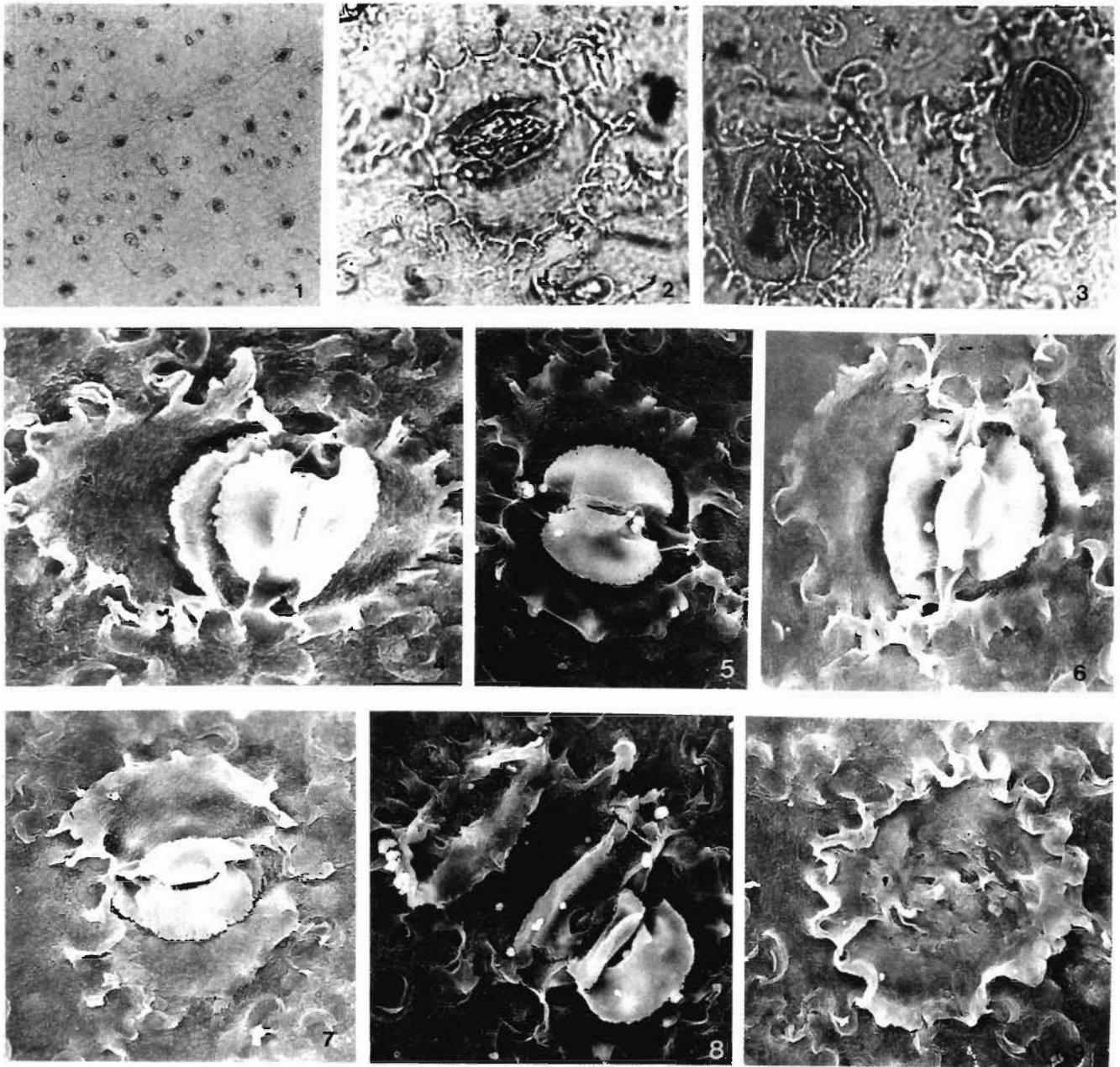
DISCUSSION AND COMPARISON

The genus *Nilssoniopteris* was emended and separated by Nathorst (1909) from the genus *Taeniopteris*. Its characters were based chiefly on *Taeniopteris*. The walls of epidermal cells are conspicuously sinuous, stomata only on the lower cuticle and syndetocheilic. This genus is chiefly found in the Jurassic and Cretaceous of the Northern Hemisphere.

The new species looks somewhat similar to *N. major* (L. et H.) Harris and *N. pristis* Harris from the Yorkshire flora (Harris, 1969, pp. 72-76, 76-79) in external form. *N. pristis* has wrinkled midrib, almost similar leaf width and vein concentration, but its margin is dentoid and not entire. *N. major* has less veins (only 6-12 per cm) and dentate margin. Both the species from England have some cuticular features different from the new species, like : both of them without trichome bases on the upper cuticles. In *N. major*, papilla are absent on the subsidiary cells covering the stomatal aperture, so its aperture opening often wider. In *N. pristis*, the width of the stomatal bands and the bands along the veins are nearly equal; in contrast, the new species has the width of stomatal bands considerably wider than along the veins. Another feature is the trichome bases consisting of mostly one cell in *N. pristis*, smaller than those in the new species (2-4 cells). *N. didaoensis* (Zheng et Zhang) Meng and *N. prynadae* Samylin 1964 from the same coal mine* appear somewhat similar to the new species in external form, but *N. didaoensis* has different venation : most veins forked once near

margins, vein concentration near the midrib 17 per cm, but near margins 28 per cm. In our species most veins simple, 18-20 per cm near margins. The important distinction is in the cuticle structures. In *N. didaoensis* the lower cuticle is thick with strongly striped thickening on the surface. Stomata concentration is larger than that in new species (80-90 per sq mm). In *N. prynadae* the venation is similar to the new species, but the cuticle structure is different : its cuticle with radiated thickening on the surface; the stomatal concentration is larger (86 per sq mm) and the trichome bases confined only on the bands along the veins.

Nilssoniopteris are also different from the new species, for instance, *N. bailarensis* Zheng et Zhang (Zheng Shaolin & Zhang Wu, 1990) from the Early Cretaceous of Hailaer Basin, north eastern Inner Mongolia, is a very narrow leaf, less than 6 mm wide, external form long-linear, surface of epidermal cells is finely granular and no trichome basis on the upper cuticle. On the lower cuticle the trichome bases are only confined in the stomatal bands, and the number is more than that of stomata. *N. beyrichii* (Schenk) Nathorst is a common species of Wealden flora of Europe. It appears in the Early Cretaceous of Fuxin coal mine north-east China (Chen Fen *et al.*, 1988, p. 56) and Zhangjiakou, Feng-ning,, Hebei Province (Wang Ziqiang, 1984, p. 264). The width of leaf is narrow (less than 2 cm), but the midrib on the upper side is wide about 1.5 mm with small swellings. Veins are simple but much crowded, 20-40 per cm, the upper cuticle shows clear bands along the veins consisting of regularly quadrate-rectangular cells, arranged in 3-4 rows. The cells in the bands between veins are obliquely quadrate or quadrate in regular rows. All these morphological features are different from the new species. *N. vittata* Harris (Harris, 1969, p. 68) from England (Yorkshire flora) and China of the Middle Jurassic (Xuanhua, Hebei prov. Wang Ziqiang, 1984, p. 256; Xiangxi, Hubei Province Wu Xiangwu, 1988, p. 754) has narrow leaf (less than 3 cm), longitudinal strips on the midrib, margin entire or slightly undulate. On the lower cuticle the width of the stomatal bands are equal or less than that of the bands along the veins, 200-250 μ m, the stomatal concentration is 34-50 per sq mm, stomata bands often contain 1-3 stomatal rows, arranged in short

**PLATE 2**

1. Lower cuticle showing 3 stomatal bands and 2 unistomatal bands along veins, non-stomatal band shows a few big trichome bases. x 16. Specimen No. 8370.
 2. Stomata showing the papilla on the middle part of the subsidiary cells. x 252. Slide No. 8372(2)
 3. Stomata (left) and trichome base (right) x 252. Slide No. 8372(3).
 - 4-9. SEM photographs showing stomata and trichome base. Stomata is syndetocheilic type with two sunken guard cells, two asymmetric subsidiary cells with coarse tooth-like projections: 4. x 960. Slide No. 8372. 5, 7, 9, 6 x 720. 6. x 780.
- (Note—Stomata and a trichome base in fig. 8 and a round trichome base in fig. 9).

longitudinal rows along the veins; the outer walls of subsidiary cells thickened, entire or irregularly undulate; the trichomes are mostly on the bands along the veins, smaller, 38 x 38-50 μm .

In *N. angustifolia* Wang (Wang Ziqiang, 1984, p. 264) from Xuanhua, Hebei Province of the Middle Jurassic, the leaf is narrow, less than 2.5 cm, vein concentration 20-40 per cm, trichome bases are large consisting of 4-5 cells. *N. inconstans* Sun & Shen (Sun Bainian & Shen Guanglong, 1988, p. 561) from Lanzhou, Gansu Province of Middle Jurassic, its external form is very distinctive: the lower part of leaf is entire but the upper one is pinnate. On the lower cuticle the bands along the veins and between the veins not distinguishable. There are a number of trichome bases but no papilla present which are different from the new species.

There are some species of *Nilssoniopteris* described by different authors, but the cuticular structures were not given in detail by them, for example, *N. ovalis* Samylin 1963, *N. ?undufolia* Wang 1984. Therefore, we could not compare them with the new species.

CONCLUSION

The Huolinhe flora is rich with the Early Cretaceous plants. The coeval floras are found in Fuxin coal mine, Tiefa coal mine of Liaoning Province and Hailaer coal mine of Northeastern Inner Mongolia. In all these floras, ginkgophytic plants and *Podozamites* are in abundance, and the coniferopsids consist of plants with needle-like leaves. The features of these floras determine that they belong to the Siberian palaeophytogeographic province. All the floras are different from the floras found in Northwest China (Gansu Province), South China (Zhejiang Province) and Xizang Autonomous region, where the occurrence of ginkgophytic plants and *Podozamites* is seldom, the coniferopsids bear scale-like leaves, and *Weichselia* and *Zamiophyllum* are the special genera which are not found in Northeast China and Inner Mongolia. Therefore, in the Early Cretaceous the floras of North-west China, South China and Xizang Autonomous region are similar to the Weald-

den flora of Western Europe, belonging to the European palaeophytogeographic province. Cycadales and Bennettiales are in abundance in Huolinhe region, suggesting a warm and humid subtropical environment in the eastern part of Inner Mongolia in the Early Cretaceous.

ACKNOWLEDGEMENTS

The authors are indebted to Y. H. Xiao and X. J. Yang for the SEM photo and to Z. Du for other photographic work. All the specimens and slides have been deposited in the Laboratory of Palaeobotany, Institute of Botany, Academia Sinica, Beijing. We also express our thanks to the Science Foundation of China, Chinese Academy of Sciences for a special support for the Palaeontological and Palaeoanthropological investigations.

REFERENCES

- Chen Fen, Meng Xiangying, Ren Shouqin & Wu Chonglong 1988. *The Early Cretaceous flora of Fuxin Basin and Tiefa Basin, Liaoning Province*. Geol. Pub. House, Beijing.
- Deng Shenghui 1991. Early Cretaceous fossil plants from Huolinhe Basin in Inner Mongolia. *Geoscience* 5(2):147-156.
- Duan Shuying, Chen Ye & Keng Kuochang 1977. Some Early Cretaceous plants from Lhasa, Tibetan Autonomous region, China. *Acta bot. sin.* 19(2):114-119.
- Duan Shuying & Chen Ye 1991. The discovery of two new species of *Eretmophyllum* (Ginkgoales) in China. *Cathaya* 3:135-142.
- Harris TM 1969. *The Yorkshire Jurassic flora. III, Bennettiales*, Brit. Mus. (Nat. His.): 1-186.
- Nathorst AG 1909. Über die Gattung *Nilssonia* Brongn. mit besonderer Berücksichtigung schwedischer Arten. *K. Svenska VetenskAkad. Handl, Stockholm* 43(12):1-40.
- Samylin VA 1963. The Mesozoic flora of the lower course of the Aldan River. *Palaeobotanica* 4:89-90.
- Samylin V 1964. The Mesozoic flora of the area to the west of Kolyma River (The Zyrianka coal-basin). 1. Equisetales, Filicales, Cycadales, Bennettiales. *Palaeobotanica* (Leningrad) 5: 75-76.
- Schenk V 1871. Beiträge Zur Flora der Vorwelt-IV Die Flora der norddeutschen Wealden-formation. *Palaeontographica* 19 :19.
- Sun Bainian & Shen Guanglong 1988. A new species of genus *Nilssoniopteris*. *Acta palaeont. sin.* 27(5):561-564.
- Wang Ziqiang 1984. Plants. In Tianjin Inst. of Geol. Min Res. (Editor)—*Palaeontological Atlas of North China* 2 : 264-266. *Mesozoic Volume*. Geol. Pub. House, Beijing.
- Wu Xiangwu 1988. Some plants of Bennettiales from Middle Jurassic Hsiangchi Formation in west Hubei, China. *Acta palaeont. sin.* 27(6): 751-758.
- Zheng Shaolin & Zhang Wu 1990. A new species of *Nilssoniopteris* from the Early Cretaceous of Hailaer Basin. *Acta bot. sin.* 32 (6): 483-489.