The significance of a Permian flora from Irian Jaya (West New Guinea) containing elements related to coeval floras of Gondwanaland and Cathaysialand

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Previous authors have identified Permian floras from the southern side of Irian Jaya as being related to coeval floras of both Gondwanaland and Cathaysialand. Some of the identifications are revised. Many species of *Glossopteris*, including *G. iriani* sp. nov., as well as *Vertebraria* align the flora with Gondwanaland, whereas *Gigantonoclea iriani* sp. nov. and *Fascipteris aidunae* sp. nov. demonstrate a clear connection with Cathaysian floras. *Trizygia speciosa* and *Pecopteris* spp. can occur in both floras. The endemic leaf species, *Koraua hartonoi* gen. et sp. nov. is compared with genera from India and southern Africa. The spermophyta required direct land connection with both Gondwanaland and Cathaysialand in order to spread into the area. This is possible using Earth reconstructions based on the Earth Expansion Theory, but not using reconstructions based on the Plate Tectonics Theory.

Key-words—Permian flora, Gondwanaland, Cathaysialand, *Glossopteris, Gigantonoclea, Fascipteris, West New Guinea*.

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सारांश

गोंडवानाभूमि एवं कैथेसिआभूमि के समकालीन वनस्पतिजातों के अवयवों से युक्त इरियन जया (पश्चिम न्यू गिनी) से प्राप्त परमियन वनस्पतिजात का महत्व

जे. एफ. रिगबी

पूर्व अनुसन्धान कर्त्ताओं ने गोंडवानाभूमि एवं कैथेसिआभूमि के समकालीन वनस्पतिजातों के समतुल्य इरियन जया के दक्षिणी ओर से परमियन वनस्पतिजात अभिनिर्धारित किये हैं। इनमें से कुछ के अभिनिर्धारण में संशोधन किया गया *ग्लॉसॉप्टेरिस इरियानाई* नव जाति सहित ग्लॉसॉप्टेरिस की बहुत सी जातियों तथा *वर्टीब्रेरियया* की उपस्थिति से यह वनस्पतिजात गोंडवानाभूमि से मिलता-जुलता है जबकि *जाइगेन्टोनोक्लिआ इरियानाई* नव जाति एवं *फासिप्टेरिस एडुनी* नव जाति की उपस्थिति कैथेसिअन वनस्पतिजात के संकेत देती हैं। *ट्राइजीजिआ स्पेसिओसा* एवं *पीकॉप्टेरिस* जातियाँ दोनों ही वनस्पतिजातों से मिलती हैं। *कोरोआ हार्टोनॉइ* नव प्रजाति व जाति की भारत एवं दक्षिणी अफ्रीका की प्रजातियों से तुलना की गई है। स्पर्मोफाइटा के दोनों ही क्षेत्रों में प्रसार हेतु गोंडवानाभूमि एवं कैथेसिआभूमि दोनों ही का संयोजन आवश्यक था। ऐसा सम्भवतः भूमि प्रसार सिद्धान्त के कारण सम्भव हो सकता है न कि प्लेट विवर्तनिक सिद्धान्त के फलस्वरूप ।

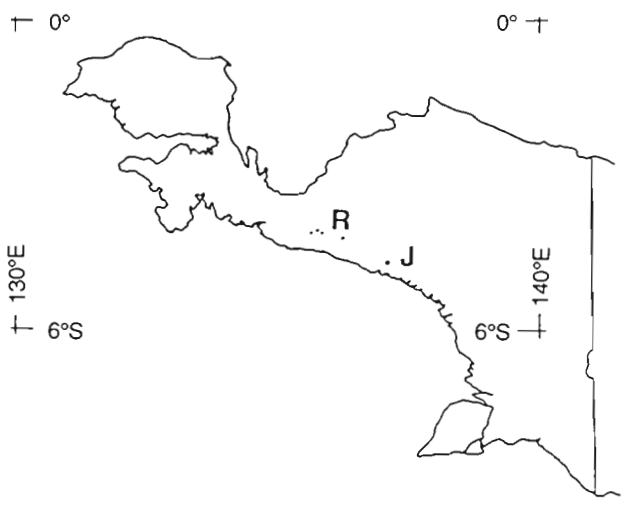
VERY little data has been published concerning the Permian floras of Irian Jaya (West New Guinea) in the past. Previous papers, discussed below, describe floras including both elements of typical Gondwanaland floras with the addition of species typically occurring in Cathaysian floras.

Jongmans (1940) described and figured a number of species, some of which I have redetermined [in square brackets] on the basis of his figures and a photograph he sent Dr A. B. Walkom in 1938. *Sphenophyllum verticillatum* (Schlotheim 1820) Brongniart 1828 [*Trizygia speciosa* (Royle 1840)

Unger 1845]; *Pecopteris* sp. cf. *P. arcuata* Halle 1927 [*Pecopteris* sp. A]; *Pecopteris* sp. cf. *P. paucinervis* Jongmans 1956 [*Pecopteris* sp. B]; *Pecopteris* sp. cf. *P. orientalis* (Schenck 1883) Potonié 1893; [*Pecopteris* sp. C]; *Pecopteris unita* Brongniart 1836 [*Fascipteris iriani* sp. nov.]; *Taeniopteris* sp. cf. *T. multinervis* Weiss 1869; *Taeniopteris* sp. cf. *T. taiyuanensis* Halle 1927; [Jongmans' photographs of both species of *Taeniopteris* appear to show cross connections between the secondary veins, so should be identified as species of *Glossopteris*]; *Vertebraria* [*Vertebraria indica* Royle 1840]. Jongmans quite appropriately based on his identifications, dated the fossiliferous horizon as Late Carboniferous.

Lehner *et al.* (1955), in an unpublished report not available to me, reported plant fossils from a number of localities in the Aiduna Formation near the headwaters of the Aiduna River. Their localities are plotted on the Waghete map sheet (Pigram & Panggabean, 1983). I do not know what species were identified.

Wagner (1962) figured and described briefly Permian plants from a number of localities in the Aiduna Formation which is the upper part of the Aifam Group, but was then known as the Aifam Formation. His locality data are not available to me, nor do they appear to be plotted on the Waghete map sheet (see Pigram & Panggabean, 1983) although they may be given in Visser & Hermes (1962), within which Wagner (1962) is a loose insert and is the only part I have seen. His identifications included : *Glossopteris* cf. *browniana* Brongniart (1828) 1831; *Glossopteris* cf. *indica* Schimper 1869; *Glossopteris* aff. *retifera* Feistmantel 1876 [Wagner said these identifications with various *Glossopteris* spp. were tentative]; *Vertebraria* sp. [*Vertebraria indica* Royle 1840]; *Taeniopteris* cf. *hallei* Kawasaki 1934 [I cannot comment because the reproduction is not sufficiently clear]; *Cladophlebis* cf. *australis* (Morris 1845) Walkom 1917 [This is a Mesozoic species. The specimen figured by Wagner differs from it by having similar, but larger pinnules. It is listed here as *Cladophlebis* sp.]; *Pecopteris monyi* Zeiller 1888 [*Pecopteris* sp.]; '*Validopteris*' sp. (sensu Stockmans & Mathieu, 1939) [*Fascipteris iriani* sp. nov.]; *Sphenophyllum* cf. *speciosum* (Royle 1840) M'-Clelland 1850 [*Trizygia speciosa* (Royle 1840) Unger 1845].



Text-figure 1—Irian Jaya (West New Guinea) showing areas where collections have been made. **J** - Specimens submitted to Jongmans (1940). **R** - Specimens submitted to Rigby, reported herein.

Further collections from the Aiduna Formation were made in 1979 and 1980 during the Irian Jaya Geological Mapping Project, a joint project of the Indonesian Geological Research and Development Centre, and the Australian Bureau of Mineral Resources, now the Australian Geological Survey Organisation. The plants were submitted to me for examination. After completing photography and some studies, a change in policy by my then employer, the Geological Survey of Queensland, dictated no more work could be done on non-Queensland fossils. An inconclusive preliminary report appeared in 1983 (Rigby, 1983). The present report is of one significant aspect of the flora, namely the occurrence of the indicator fossil genera for the Permian of Gondwanaland and Southern Cathaysialand, *Glossopteris* and *Gigantonoclea* respectively, occurring on the same slab of rock from locality 80 BH 302 D. This locality and others relating to the collections discussed by Lehner *et al.* (1955), and Rigby (1983) are plotted on maps 2 and 3 in Rigby (1983). No other locality information is available.

All collections were from the southern (Gondwanaland) side of the main suture zone on part of the Australasian plate. The 1979 and 1980 collections will be lodged with the Australian Geological Survey Organisation, Canberra.

The flora includes a number of species, only three of which are discussed herein as they provide the

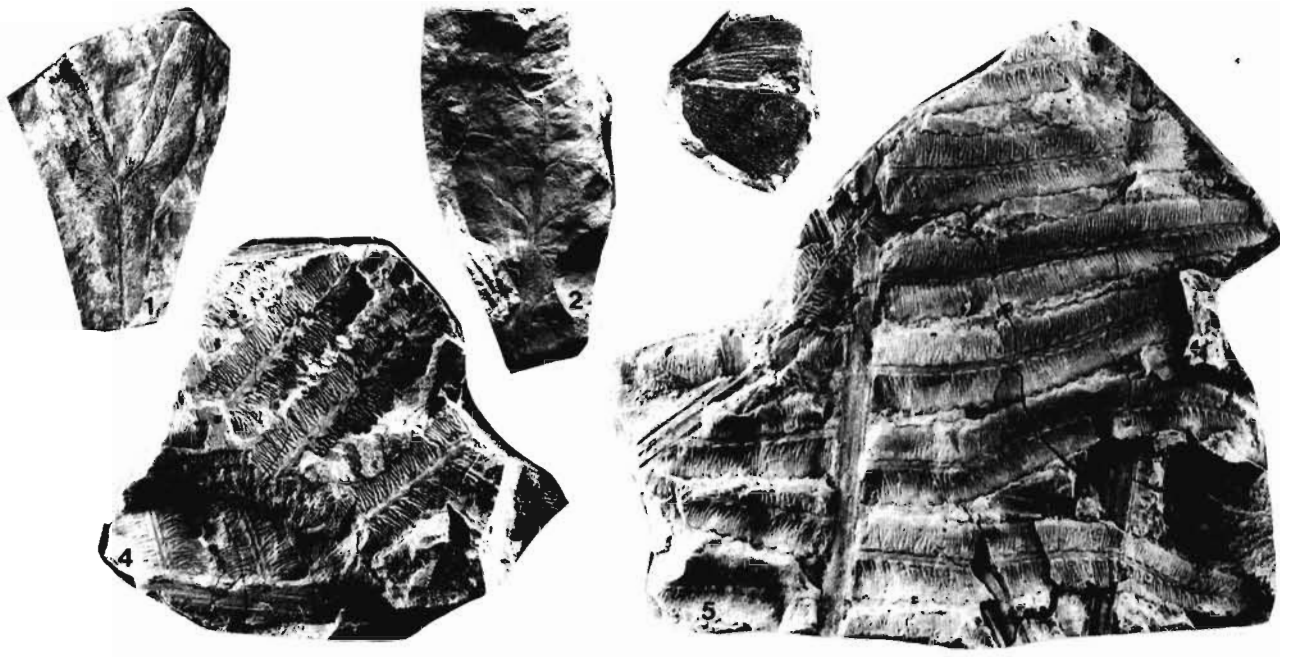


PLATE 1

All figures x natural size.

1. *Koraua hartonoi* gen. et sp. nov. Single, dichotomously forked leaf. Paratype, 80 AG 64P.
2. *Gigantonoclea iriani* sp. nov. Holotype, 80 BH 302D.
3. *Trizygia speciosa* Royle 1840. Two adjacent leaves from a single whorl. 80 AG 64B.
4,5. *Fascipteris aidunae* sp. nov. 79 RY 188C. 4. Holotype. 5. Paratype.

principal evidence that, at the time of growth, there was direct connection between the area of sedimentation of the Aiduna Formation, Gondwanaland and the southern province of Cathaysialand. Two are endemic species of the seed-bearing plants *Glossopteris* and *Gigantonoclea* both occurring on the same rock slab. There was no animal vector for the dispersal of seeds over the broad Tethys Ocean postulated to exist by the Plate Tectonics Theory, thus the locality must have had direct contact with both continents, this will be discussed further, below. The flora also included a number of sporophytes having affinities with the floras of one or the other continent, namely *Pecopteris* spp. and *Trizygia speciosa*, but as spores may be dispersed over long distances by wind, no land connection need have been in existence. An exception is *Fascipteris*, described below, previously known only from the southern Cathaysialand province, but here one occurrence is together with typical Gondwanaland species at the locality Jongmans (Table 1).

PALAEOBOTANY

Glossoperis Brongniart (1828) 1831

Glossopteris iriani sp. nov.

Text-figure 2F; Pl. 2, figs 1, 2

Description—Narrowly obovate leaf, apex acute, contracting very gradually basally, midrib broad over more than half the length narrowing towards the apex; secondary venation curving gently from the midrib to the margin, degree of arching 7°, marginal angle 55°, cross connections rare, occurring more commonly near the midrib. Cuticle and fructification unknown.

Comparison—This species does not resemble any species from Australia, South America or India in venation pattern. *Glossopteris symmetrifolia* from southern Africa has a similar venation, but is a larger, ovate, much broader leaf.

Material—80 BH 302D, holotype (Text-figure 2F, Pl. 2, fig.1), paratype; 80 P 279A, 11 examples, including the specimen Pl. 2, fig. 1; 79 RY 189A, one example; 79 SS 7, one example.

Text-figure 2—Figure A, B, approximately x 1.5; figure C, diagrammatic; other figures natural size. **A-C** *Gigantonoclea iriani* sp. nov. **A**. Pattern of primary (midrib) and secondary venation: and **B**. with the tertiary venation superimposed; A and B drawn from the holotype. **C**. Mode of branching in the tertiary vanation. Irregularities have been caused by wrinkling of the specimen prior to burial, and the state of preservation. **D**. *Glossopteris* sp. H. 79 RY 189A. **E.** *Pecopteris* sp. A (=*Pecopteris* sp. cf. *P. monyi* of Wagner; 1962). **F**. *Glossopteris iriani* sp. nov. Holotype. 80 BH 302D. **G.** *Glossopteris* sp. F. 79 RY 189A. **H.** *Glossopteris* sp. C. 79 RY 189A. **I.** *Fascipteris aidunae* sp. nov. Holotype 79 RY 188C.

Origin of name—From Irian Jaya, the name of the Indonesian province.

***Gigantonoclea* Koidzumi 1936 emend. Gu & Zhi 1974**

Gigantonoclea iriani sp. nov.

Pl. 1, fig 2; Text-figure 2A-C

Diagnosis—Leaf of fused pinnate structures, numbers of pinnate lobes no more than two per secondary vein.

Comparison—All other species of this genus, in fact, all other gigantopterids have large numbers of pinnate lobes along each secondary vein. The leaf is small, but it may have been a leaflet from a multifoliate leaf similar to the trifoliate leaves described by Yang (1987) which evolved during the Late Permian, e.g., *G. spatulata* Yang 1987.

Material—80BH 302D, holotype (Pl.1, fig. 2; Text-figure 2A, B)

Origin of name—From Irian Jaya, the name of the Indonesian province.

***Fascipteris* Gu & Zhi 1974**

Fascipteris aidunae sp. nov.

Pl. 1, figs 4,5; Text-figure 2 I

Table 1—Permian floras of the Aiduna Formation, Irian Jaya (West New guinea)

Localities : Jongmans' (1940) samples were collected near the headwaters of the Otakwa River. No details of Wagner's (1962) localities are known to me, numbered 8, 10-14. I have examined specimens from the remaining localities collected by geologists from the Irian Jaya Geological Mapping Project during 1979 and 1980, numbered 79 and 80, followed by the collectors' initials, and locality number. '

Footnotes referring to species.

1. *Trizygia speciosa*. Li & Rigby (1995) have referred to unresolved problems concerning its generic attribution to *Trizygia* or *Sphenophyllum* 2. *Pecopteris* sp. A = *P.* cf. *orientalis* in Jongmans; *P. monyi* in Wagner. 3. *Pecopteris* sp. B = *P.* cf. *arcuata* in Jongmans. 4. *Pecopteris* sp. C = *P.* cf. *paucinervis* in Jongmans. 5. These are indeterminate fern frond fragments, with an outline resembling *Pecopteris*. 6. I cannot offer an opinion on Jongmans' identification of *Ptychocarpus* based on the figured specimen. 7. *Cladophlebis* sp. = *C.* cf. *australis* of Wagner, a species with pinnules less than half the relative length than the Irian Jaya specimen. 8. *Glossopteris* sp. A = a narrower form of *Glossopteris iriani* sp. nov. 9. *Glossopteris* sp. B = G. cf. *browniana* of Wagner. 10. *Glossopteris* sp. C = *G.* cf. *indica* of Wagner. 11. *Glossopteris* sp. D = *G.* cf. *retifera* of Wagner. 12. *Glossopteris* sp.F = *Taeniopteris* cf. *multinervis* of Jongmans. This and the next species both have rare cross veins. 14. *Glossopteris* sp. G = *Taeniopteris* cf. *taiyuanensis* of Jongmans.

SPECIES Numbers refer to footnotes	LOCALITIES	Jongmans	Wagner 8	Wagner 10	Wagner 11	Wagner 12	Wagner 13	Wagner 14	79 SS 7	79 CP 201	79 RY 188C	79 RY 189A	80 AG 64B	80 BH 302D	80 P 201A	80 P 201B	80 P 201C	80 P 278A	80 P 279A	80 UH 200C
Trizygia speciosa[1]		+			+								+	?						
Pecopteris sp. A[2]		+	+															+	+	
Pecopteris sp. B[3]		+																		
Pecopteris sp. C[4]		+																		
fern frond[5]									+	+										+
Ptychocarpus sp.[6]		+																		
Cladophlebis sp.[7]						+														
Fascipteris aidunae sp. nov		+			+						+									
Glossopteris iriani sp. nov.									+			+		+					+	
Glossopteris sp. A[8]									+									+		
Glossopteris sp. B[9]				+																
Glossopteris sp. C[10]							+		+			+								
Glossopteris sp. D[11]							+												+	
Glossopteris sp. E[12]								+												
Glossopteris sp. F[13]		+							+			+								
Glossopteris sp. G[14]		+							+											
Glossopteris sp. H												+							+	
Glossoptens sp. indet												+				+				
Vertebrana indica		+					+								+	+	+			
Gigantonoclea iriani sp. nov.														+						
Koraua hartonoi gen. et sp. nov.													+							

Diagnosis—Pinnate frond with strong primary rib in each pinnule, secondary venation sympodially branching, occasional veins unbranched, pinnule margin more or less parallel over most of its length, not serrate or otherwise indented, pinnules up to four times as long as broad. Other data unavailable.

Discussion—Jongmans (1940) named his specimen as *Pecopteris unita*. This is inappropriate as *P. unita* has a primary midrib in each pinnule with paired opposite veins along its length. Wagner (1962) identified a similar specimen *Validopteris* sp. (sensu Stockmans & Mathieu) which also had a primary vein and branching secondary veins in each pinnule. Gu and Zhi (1974) recombined the species as *Fascipteris hallei*, a species differentiated from *F. aidunae* by longer and more frequently sympodially branching ultimate lobes and pinnules less than four times as long as broad.

Material—79 RY 188C, holotype (Pl. 1, fig. 5; Text-figure 2 I), paratype (Pl.1, fig. 4), at least 7 other matted specimens. Other specimens in the collections examined by Jongmans (1940) and Wagner (1962).

Origin of name—From the Aiduna Formation in which it occurs.

***Koraua* gen. nov.**

Diagnosis—Small, Y-shaped leaf, sessile, margin entire; arranged into tufts or whorls, leaves within the tuft are similar; about half way along the leaf the midrib dichotomizes, just below a deep medial incision dividing the upper half into two symmetrical lobes with rounded apices; secondary venation glossopterid, asymmetrical within each lobe but bilaterally symmetrical over the complete leaf.

Comparison—*Benlightfootia* Lacey & Huard-Moine 1966 from southern Africa and India had a dichotomous leaf, but did not have a dichotomizing midrib. *Pachwarophyllum* Prasad & Maithy 1990 from India lacks any distinct midrib. *Diphyllopteris* Srivastava 1978 from India had leaves of very different morphologies within each tuft or whorl.

Type species—*Koraua hartonoi* sp. nov.

Origin of name—From the Korau River beside which the type specimen was found.

Koraua hartonoi sp. nov.

Pl. 1, fig.1; Pl. 2, fig. 6; Text-figure 3

Diagnosis—Secondary venation arched with an average of one dichotomy between the midrib and margin, and with between none and two cross connections between adjacent veins, some ribbing along the midrib as in *Glossopteris*.

Comparison—The genus is monotypic.

Material—80 AG 64B, holotype (Pl. 2, fig. 6; Text-figure 3), paratype (Pl. 1, fig. 1).

Origin of name—*hartonoi* in honour of Dr Hartono of the Geological Research and Development Bureau, Bandung, Indonesia.

Other species figured and listed on Table 1 are not discussed as further work is needed.

Text-figure 3—*Koraua hartonoi* sp. nov. Whorled or tufted specimen borne on a longitudinally ribbed stem. 80 AG 64B. Paratype.

DISCUSSION AND CONCLUSIONS

The genera found in the Aiduna Formation widely known from elsewhere fall into four categories:

1. Typically from the Permian of Gondwanaland—*Glossopteris, Vertebraria*;
2. Typically from the Permian of Cathaysialand—*Gigantonoclea, Fascipteris*;
3. May occur in either region—*Pecopteris, Trizygia*;
4. Endemic, not known from elsewhere—*Koraua*.

Of these, *Glossopteris, Vertebraria* and *Gigantonoclea* belonged to seed plants so these are most significant because of limitations on seed dispersal.

The combinations of 1 and 2 occur in only two localities in Irian Jaya: Jongmans and 80 BH 302D (see Table 1). At the latter locality *Gigantonoclea* and *Glossopteris* occur on the same rock slab. Here the representatives from each flora must have been growing side by side, hence land communication must have been possible with both Gondwanaland and Cathaysialand more or less simultaneously. There was no means available to transport seeds over a broad Tetl ys Ocean whose existence was postulated by the Plate Tectonics Theory. Instead, close contact between both areas must have existed across a narrow, often transient Tethys Sea as postulated by the Earth Expansion Theory.

PLATE 2

All figures x natural size.

1-2. *Glossopteris iriani* sp. nov. 16. 80 P 279A.
2. Holotype. Although this is not the most perfect specimen, it is the most significant as it shares the same rock slab as the holotype for *Gigantonoclea iriani*. 80 BH 302D.
3. *Glossopteris* sp. G (=*Taeniopteris* sp. cf. *T. taiyuanensis* of Wagner, 1962). 79 SS 7.
4. *Glossopteris* sp. A. 79 SS 7.
5. *Glossopteris* sp. F (*Taeniopteris* sp. cf. *T. multinervis* of Wagner, 1962). 79 SS 7.
6. *Koraua hartonoi* sp. nov. Incomplete whorl or tuft attached to an apparently longitudinally ribbed stem. 80 AG 64 B. Holotype
7. *Glossopteris* sp. C. 79 RY 189A.
8. *Glossopteris* sp. F. 79 RY 189A.
9. *Glossopteris* sp. H. 79 RY 189A.
10. *Pecopteris* sp. A (=*Pecopteris* sp. cf. *P. monyi* of Wagner, 1962).

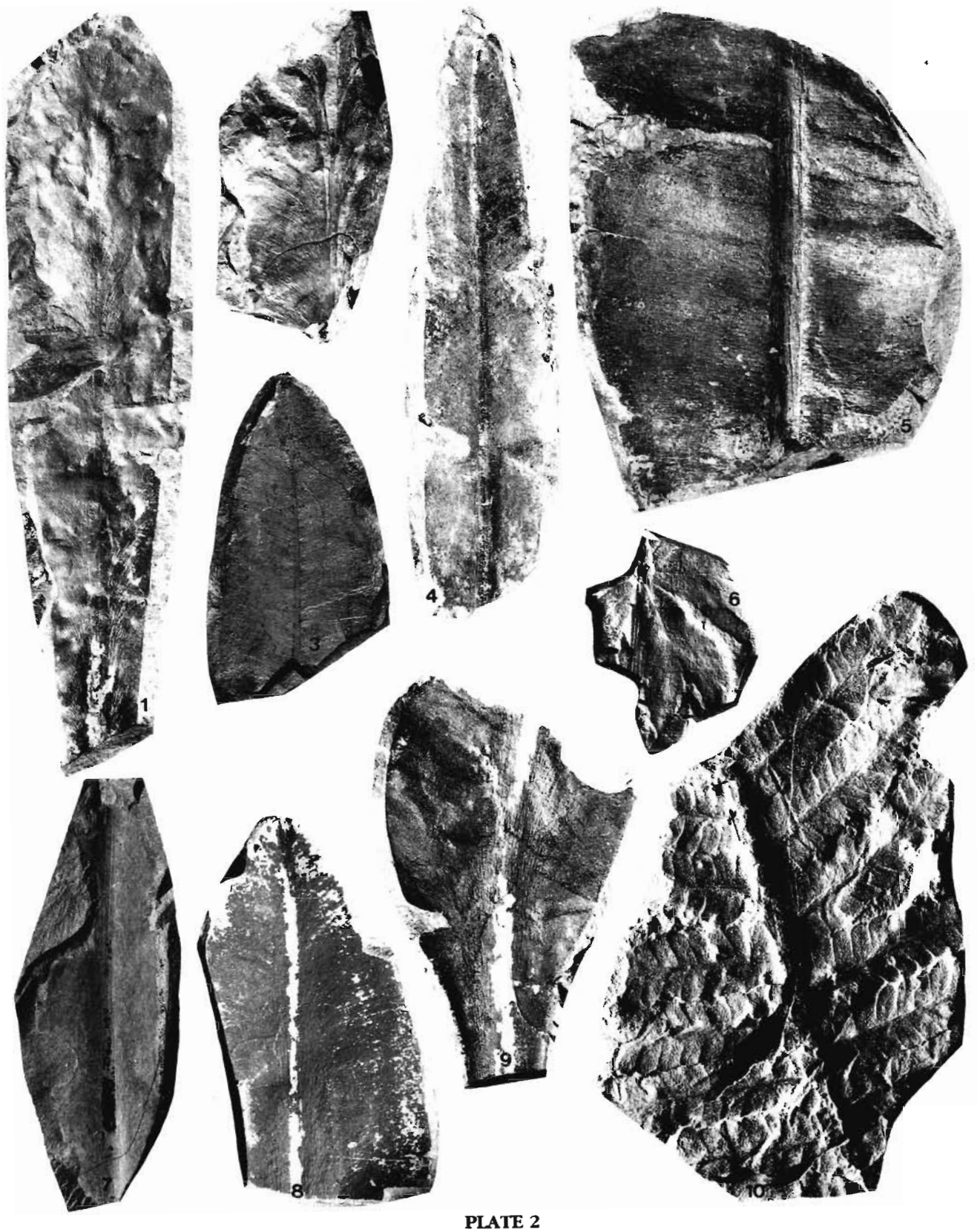


PLATE 2

Various *Pecopteris* species occurred throughout the tropical - warmer regions of the Permian including the parts of Gondwanaland nearer the palaeoequator so the presence of sporophytic species is not particularly significant. *Fascipteris aidunae,* probably, and *Trizygia speciosa,* certainly were spore-bearing. Spores were capable of air transport so transoceanic inoculation was possible, although *Fascipteris* is known only in Cathaysian floras occurring in all Permian floral provinces of China except in the north west (Shen, 1995).

I do not agree with the concept of mixed floras, I prefer regarding this as an overlap between the tropical Cathaysian and temperate Gondwanan floras. Regions having species from each flora probably were warm temperate to sub-tropical, providing there was land communication for the flora to migrate along. Irian Jaya was one such place.

ACKNOWLEDGEMENTS

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