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pp. 461-505, text-fig. 1, pls 1-17

THE WESTPHALIAN D FLORAS OF THE OLLONIEGO AND ESPERANZA FORMATIONS IN THE CENTRAL ASTURIAN COALFIELD

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ABSTRACT

Lower to middle Westphalian D floras are figured and described from the Olloniego and Esperanza formations in the north-western part of the central Asturian coalfield. This includes one new species, *Sphenopteris pelloi*. These floras are discussed in relation to the general succession of coal-measure floras of Westphalian D age in Asturias, Palencia and León.

RESUMEN

Unas floras de edad Westfaliense D inferior a medio son descritas de las Formaciones Olloniego y Esperanza en la parte nor-occidental de la Cuenca Central de Asturias. Se adjunta una figuración completa que incluye la de una especie nueva, *Sphenopteris pelloi*. Las floras descritas son situadas dentro de la sucesión de floras del Westfaliense D de varios lugares de Asturias, Palencia y León, llegándose a la conclusión de que la flora de la Formación Esperanza, del Westfaliense D inferior, es ligeramente más antigua que la flora del Westfaliense D inferior a medio de la Formación Olloniego. La sigue la flora de la Formación Ablanedo, del Westfaliense D medio. Son más modernas las floras del Westfaliense D superior de Ocejo de la Peña (León) y del Sinclinal de Casavegas (Palencia).

INTRODUCTION AND ACKNOWLEDGEMENTS

The floral remains described in the present paper were collected in 1964 from localities discovered by J. PELLO (University of Oviedo) in the course of mapping the lithostratigraphic units along the north-western border of the central Asturian coalfield. Special attention was paid to the dating of a disconformable conglomerate formation at Olloniego and to its relative position with regard to other formations in this part of the coalfield (PELLO 1968). After initial collecting by PELLO a more complete representation of flora in this conglomerate formation was obtained by a joint excursion during which two localities (14 and 15) were sampled fairly exhaustively.

The fossil collection was studied in the Department of Geology at the University of Sheffield, where the material prepared for illustration was photographed by

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Mr. B. PIGOTT. The collection has been lodged at the Department of Palaeontology at the University of Oviedo, and the numbers prefixed DPO refer to the Catalogue at this Department.

The writer is indebted to Mr. PELLO for the opportunity to study these floral remains and for provision of the general map reproduced here as text-fig. 1. He gratefully acknowledges the technical assistance of Mr. PIGOTT, and also wishes to record his appreciation for helpful discussion by Mr. J. A. KNIGHT (Sheffield).

LITHOSTRATIGRAPHIC UNITS AND LOCALITIES STUDIED

During a palaeobotanical and stratigraphic study of the coal-measures at Riosa, in the north-western part of the central Asturian coalfield (JONGMANS & WAGNER 1957), it was found that ADARO's standard lithological units established on the basis of the succession in the Nalón Valley had been misidentified in the Riosa area. A local succession was therefore recognized by these authors, who distinguished the following informal units of Westphalian C and D ages: Canales-Piedrafita, Pudingas, Esperanza, Ablanedo. Three of these units were subsequently referred to as formations (WAGNER 1962[a]), without however providing a proper description. The Canales Formation was dated as upper Westphalian C reaching into basal Westphalian D, the Esperanza Formation as lower Westphalian D and the Ablanedo Formation as upper Westphalian D. The latter age attribution was modified subsequently to middle Westphalian D, after finding a later Westphalian D flora at Ocejo de la Peña in north-eastern León (WAGNER 1959[c]).

The strata at Ablanedo were not found in continuous succession with those of the Esperanza Formation and the more complete regional study by PELLO (1968) showed that these two coal-measure formations were separated by a disconformable limestone conglomerate sequence which was well developed at Olloniego (compare text-fig.1). The following succession of lithostratigraphic units is now recognized by PELLO (*in* PELLO & CORRALES 1971):

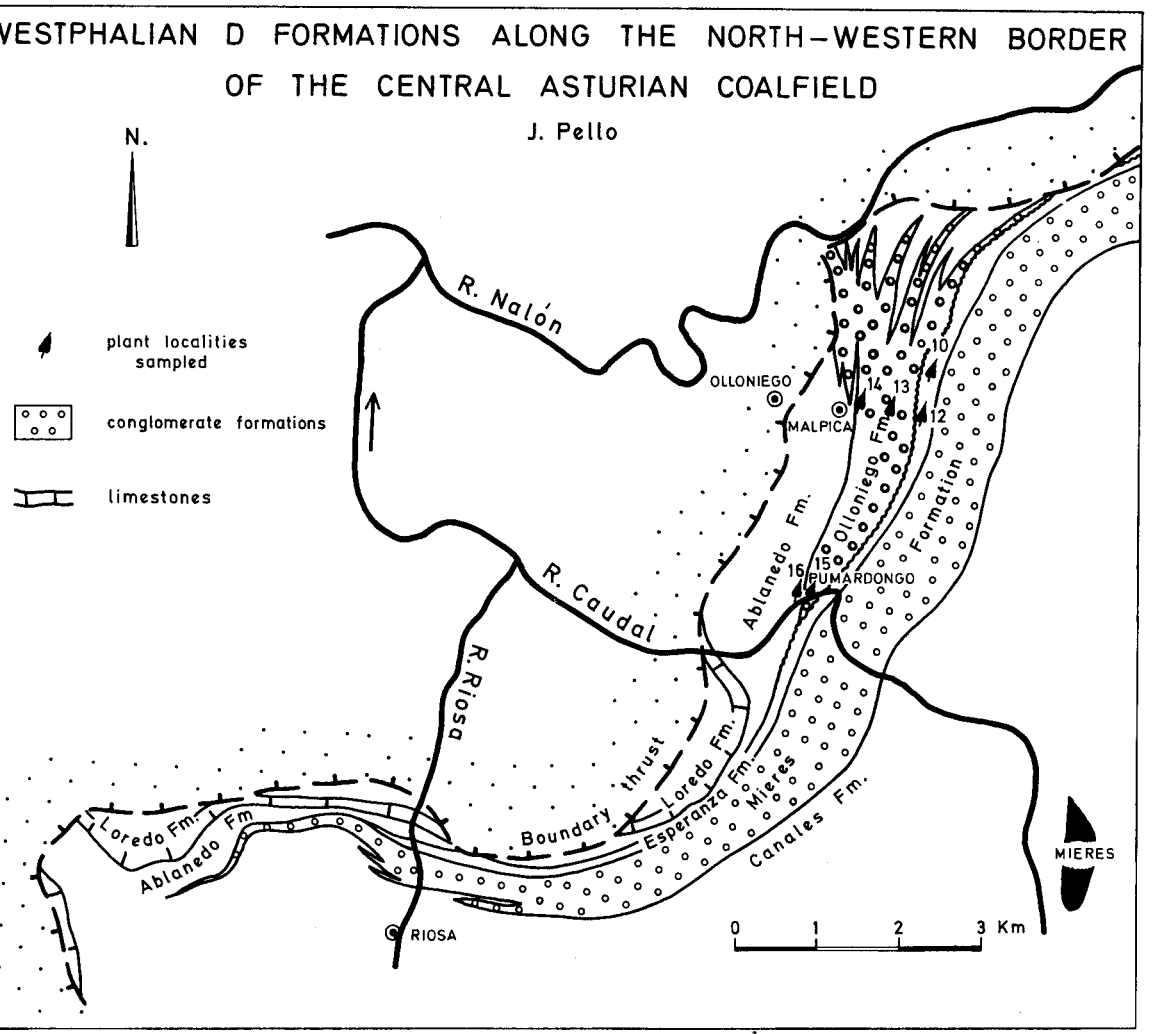
6.—L o r e d o F o r m a t i o n (maximum thickness 150 metres, as visible below the north-west boundary thrust of the central Asturian coalfield): coal-measures and marine strata including limestones.

5.—A b l a n e d o F o r m a t i o n (230-500 metres thick): coal-measures and marine strata: some of the coals were worked in the past.

4.—O l l o n i e g o F o r m a t i o n (up to 800-1000 metres thick): poorly sorted limestone conglomerates with intercalated sandstones, lutites, occasional limestones and coal seams.

3.—E s p e r a n z a F o r m a t i o n (maximum thickness *ca.* 300 metres): sandstones, lutites, a few quartzite conglomerate bands and occasional coals; one marine horizon has been recorded by CARIDE & GARCÍA-LOYGORRI (1969).

2.—M i e r e s F o r m a t i o n (maximum thickness 700 metres, but strongly wedging): poorly sorted quartzite boulders in a quartz-arenitic matrix; coal-measure intercalations present.



Text-fig. 1.—Sketch map of the different formations of Westphalian D age found in the north-western part of the central Asturian coalfield (after PELLO *in* PELLO & CORRALES 1971). Devonian to Namurian strata are thrust over these formations from the north-west.

1.—Canales Formation (maximum thickness *ca.* 800 metres): paralic coal-measures with some quartzite conglomerate bands in the upper part.

The Canales Formation contains the principal seams of this part of the central Asturian coalfield. Its age has been given as upper Westphalian C and basal Westphalian D. (JONGMANS & WAGNER 1957, CARIDE & GARCÍA-LOYGORRI 1969). The Mieres Conglomerate Formation is poorer in fossils, but certainly belongs to the Westphalian D. The Esperanza Formation has been dated as lower Westphalian D by JONGMANS & WAGNER (1957) and CARIDE & GARCÍA-LOYGORRI (1969), on the basis of

floras which are summarized in Table I. These include some remains from newly discovered localities discussed in the present paper. The Olloniego Formation has yielded some well preserved and varied floras which are described here, and which indicate a lower to middle Westphalian D age. The Ablanedo Formation has provided JONGMANS & WAGNER (1957) with middle Westphalian D floras which have been listed but which are not yet described. These will be commented upon in the following pages. The Loredo Formation has not yet provided any floral remains.

The following fossil localities, explored by Mr. J. PELLO, have yielded the floral remains described in the present paper.

Locality 10: Tip of an abandoned coal mine at 2 km north-east of Olloniego; top part of the Esperanza Formation:—*Linopteris obliqua* (BUNBURY) ZEILLER, *Callipteridium (Praecallipteridium) armasi* (ZEILLER) WAGNER, *Dicksonites potieri* (ZEILLER) P. BERTRAND, *Sphenopteris nummularia* VON GUTBIER, *Sphenopteris chaerophylloides* (BRONGNIART) PRESL, *Sphenopteris* cf. *sewardi* KIDSTON, *Sphenophyllum* sp., *Calamites* sp.

Locality 12: Surface exposure in an abandoned road cutting, near Malpica, at 1.5 km east of Olloniego; top part of the Esperanza Formation:—*Neuropteris* cf. *tenuifolia* (VON SCHLOTHEIM) BRONGNIART, *Linopteris obliqua* (BUNBURY) ZEILLER, *Annularia sphenophylloides* (ZENKER) VON GUTBIER.

Locality 13: Surface exposure at 1.3 km east of Olloniego; Olloniego Formation:—*Linopteris obliqua* (BUNBURY) ZEILLER.

Locality 14: Surface exposure in an abandoned road cutting at Malpica, 700 metres east of the level crossing at Olloniego; at 15 metres below the top of the Olloniego Formation:—*Neuropteris scheuchzeri* HOFFMANN, *Linopteris obliqua* (BUNBURY) ZEILLER, *Alethopteris grandinioides* KESSLER var. *grandinioides*, *Dicksonites* cf. *potieri* (ZEILLER) P. BERTRAND, *Alloiopteris cristata* (VON GUTBIER) NĚMEJC, *Sphenopteris pelloi* sp.nov., *Sphenopteris nummularia* VON GUTBIER, *Sphenopteris* cf. *amoena* (STUR) KIDSTON, *Palmatopteris membranacea* (VON GUTBIER) STERZEL, *Aphlebia* sp., *Pecopteris (Lobatopteris) (Asterotheca) miltoni* (ARTIS) BRONGNIART, *Pecopteris* cf. *obliquenervis* CORSIN, *Sphenophyllum emarginatum* BRONGNIART.

Locality 15: Roof shales of a coal smut in a road exposure at Pumardongo (La Pereda), at 2.3 km south of Olloniego; at *ca.* 30 metres from the top of the Olloniego Formation:—*Alethopteris grandinioides* KESSLER var. *grandinioides*, *Mariopteris (Fortopteris) latifolia (non* BRONGNIART?) ZEILLER, *Dicksonites potieri* (ZEILLER) P. BERTRAND, *Alloiopteris erosa* (VON GUTBIER) D. WHITE, *Sphenopteris opulenta* DANZÉ, *Sphenopteris* sp., *Pecopteris (Lobatopteris) serpentigera* WAGNER, *Pecopteris unita* BRONGNIART, *Pecopteris (Asterotheca) punctata* CORSIN, *Sphenophyllum orbiculare* REMY, *Sphenophyllum trichomatosum* STUR.

Locality 16: Tip of the Mina Postrera, near Pumardongo (La Pereda), at 2.3 km south of Olloniego; Ablanedo Formation:—*Mixoneura* sp. (cf. *peyerimhoffi* P. BERTRAND), *Linopteris obliqua* (BUNBURY) ZEILLER.

After the older authors (e.g. ZEILLER 1882) established the general Westphalian age («Houiller moyen») of the productive coal-measures in the central Asturian coalfield, the first systematic attempt at dating these deposits more exactly was made by JONGMANS (1951, 1952), who also presented the first atlas of floral elements collected in this coalfield. He concluded that Westphalian C and Westphalian D measures were present as well as basal Stephanian. The latter age determination was based however, on species which later proved to have been misidentified (WAGNER 1959[b]). JONGMANS (1951, 1952) also recognized the presence of Westphalian A flora in the La Camocha coal mine near Gijón, north of the central Asturian coalfield. Since the first dating of these Asturian coal-measures was based on spot samples, a systematic programme of collecting floras in sequence was initiated by Professor JONGMANS in 1952. The present writer was associated with collecting expeditions to the La Camocha mine, where a fully sampled stratigraphic section was obtained, and to the Riosa area in the north-western part of the central Asturian coalfield. The stratigraphic results of the investigations in the Riosa area were published by JONGMANS & WAGNER in 1957. Only a general list of flora identified by JONGMANS from La Camocha was published *in* WAGNER 1959[b], and the systematic description of these Asturian coal-measure floras suffered a considerable setback with the sudden death of Professor JONGMANS in 1957. Some remains of *Alethopteris* were figured and described by WAGNER (1968), but no further progress was made on the main collections of these Upper Westphalian floras.

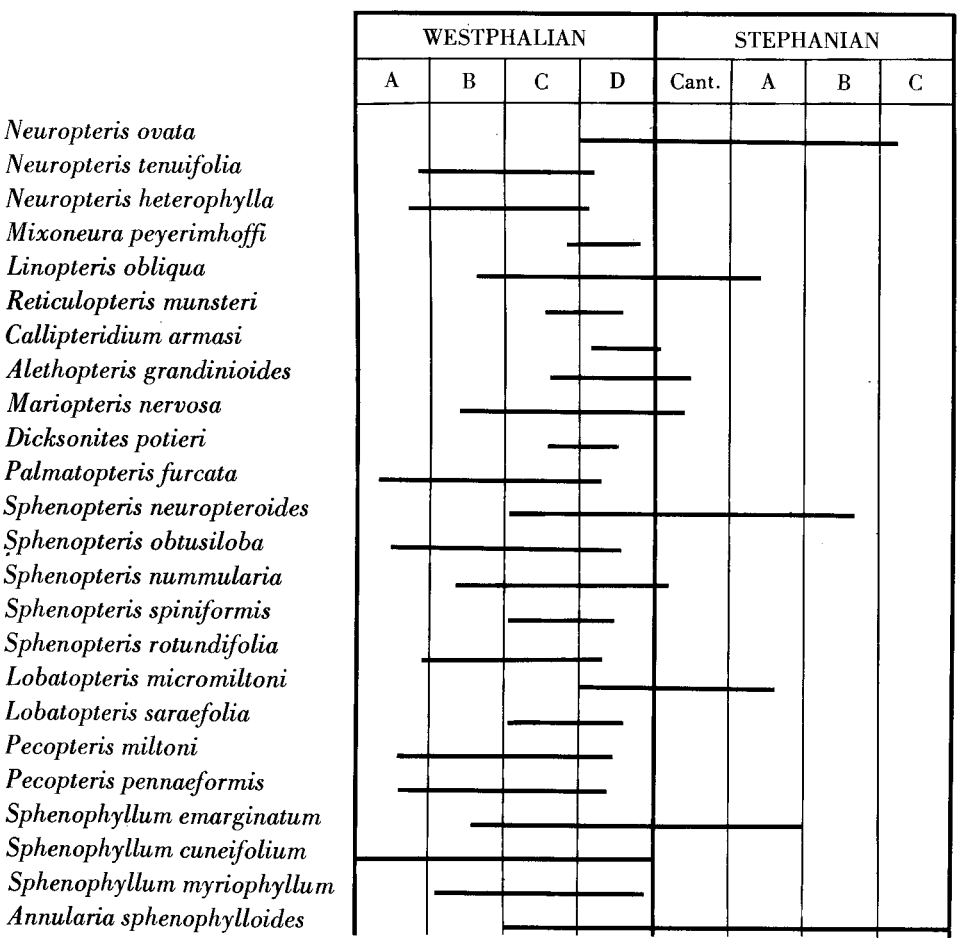
Meanwhile, CARIDE DE LIÑÁN & GARCÍA-LOYGORRI (1969) re-investigated the stratigraphy of the Riosa area and reported on the fossil flora of several formations in this region, confirming the dating established by JONGMANS & WAGNER (1957) and adding several new elements to the floral lists of the Canales and Esperanza formations. Both papers on the Riosa area lacked information on the Olloniego Formation which appeared several kilometres to the north-east and which, according to PELLO (1968), lies disconformably on the Esperanza Formation. Its stratigraphic position in between the Esperanza and Ablanedo formations appears to be confirmed by the fossil flora found in localities 14 and 15, and which is described in the present paper.

From the southern part of the central Asturian coalfield a small flora of Westphalian C age was described from the Mina Inés (WAGNER 1962[b]), and a late Westphalian B florule has been illustrated from rocks in northern León which form the continuation of strata in the Asturian coalfield (WAGNER *in* MOORE *et al.* 1971). From the north-eastern part of the central Asturian coalfield, i.e. from the area containing the type sequence of lithostratigraphic units established by ADARO (1914), a rather limited flora has been recorded most recently by VAN AMEROM *in* VAN AMEROM, BLESS & WINKLER PRINS (1970). This flora, from one of the highest rock units recognized in the north-eastern part of the central Asturian coalfield, was tentatively attributed to the basal Stephanian by VAN AMEROM, but could very well belong to the Westphalian D. A basal Stephanian age is also suggested by GARCÍA-LOYGORRI *et al.* (1971) for the highest measures in the Nalón area, even though the floral elements mentioned (compare GARCÍA-LOYGORRI *in* «Account of the International Field Meeting on the

Carboniferous of the Cordillera Cantábrica», in Part I of this volume) could just as well be found in late Westphalian D strata.

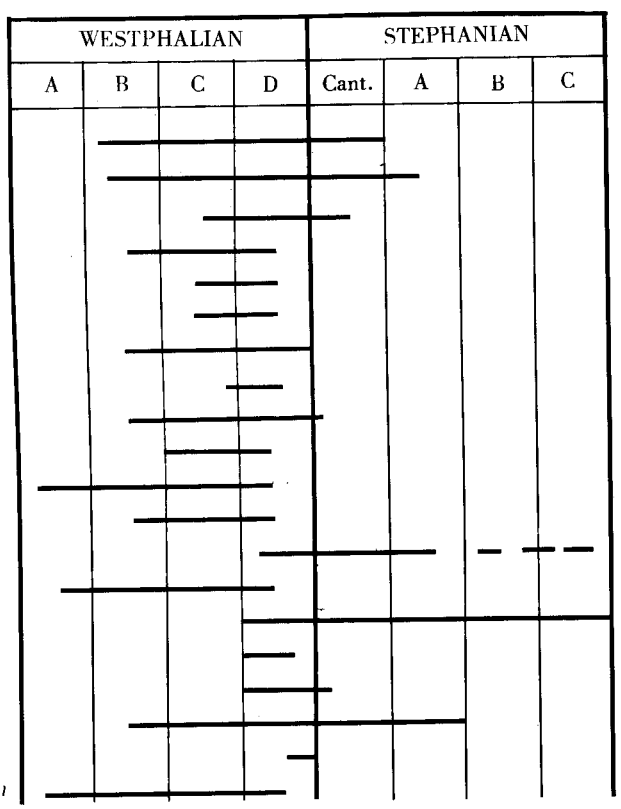
The most complete floras of the central Asturian coalfield have been found in the north-western part of this coalfield, i.e. including the Riosa area and the region between Mieres and Olloniego (text-fig.1). A list of the most important species found in the Esperanza Formation (Table I) shows a mixture of generally Middle Westphalian elements with a number of species which appear for the first time in Westphalian D strata. This floral assemblage is assigned a lower Westphalian D age. Most remarkable is the presence of *Callipteridium armasi* (Pl. 1, fig. 5, Pl. 2, fig. 1), which is generally recorded from late Westphalian D strata but which is known to occur very sporadically in earlier Westphalian D rocks.

Table I.—Chart showing the stratigraphic ranges of the most important plant fossils found in the Esperanza Coal-bearing Formation (after JONGMANS & WAGNER 1957, CARIDE & GARCÍA-LOYGORRI 1969, and new data).



A composite list of flora from the Olloniego Formation (Table II), based on localities 14 and 15, shows fewer Middle Westphalian elements (such as *Pecopteris miltoni*) and the incoming of at least two Westphalian D and Stephanian species, viz. *Pecopteris unita* and *Lobatopteris (Pecopteris) serpentigera*. It also contains a number of species which are characteristically Westphalian in age and which do not seem to reach into late Westphalian D. Worthy of note is the presence of two species which have been recorded by GUTHÖRL (1952, 1957) from Westphalian C/D boundary measures (i.e. the Geisheck Schichten) in the Saar/Lorraine coalfield. These are *Sphenopteris pelloi* (recorded by GUTHÖRL as *Sphenopteris obtusiloba*) and *Dicksonites potieri* (probably synonymous with *Dicksonites geishecki*). Two species of *Pecopteris*, i.e. *P. obliquenervis* and *P. punctata*, which were described by CORSIN (1951) from the Saar/Lorraine area, are apparently restricted to Westphalian D or thereabouts. The general impression of the Olloniego flora is that it belongs to the lower half of Westphalian D, and probably to the upper part of the lower Westphalian D. *Sphenophyllum orbiculare*, described from the upper Westphalian D of Saar/Lorraine, is too little known in its stratigraphic occurrence to modify this impression.

Table II.—Chart showing the stratigraphic ranges of the species found in the Olloniego Conglomerate Formation (localities 14 and 15).



The Ablanedo flora, as recorded by JONGMANS & WAGNER (1957), contains species such as *Dicksonites pluckeneti* (VON SCHLOTHEIM) STERZEL and *Sigillaria brardi* BRONGNIART, which appear for the first time in middle Westphalian D strata, and which are more common in the Stephanian. Two Middle and Upper Stephanian species, *Pecopteris daubreei* ZEILLER and *Sphenophyllum* cf. *angustifolium* GERMAR, mentioned from Ablanedo in the 1957 paper, should rather be assigned to *Pecopteris lobulata* DALINVAL and *Sphenophyllum guerreiroi* TEIXEIRA. Several other pecopterids from Ablanedo are either new species or represent Westphalian elements. The Ablanedo Formation is regarded as being of middle Westphalian D age.

Later, upper Westphalian D floras have been described from the unconformable, post-Leonian strata at Ocejo de la Peña in north-eastern León (WAGNER 1959[c], 1966) and from disconformable post-Leonian deposits in northern Palencia (WAGNER & VARKER 1971). These floras are characterized, in particular, by *Callipteridium (Praecallipteridium) jongmansi* (P. BERTRAND) WAGNER, *Alethopteris robusta* LESQUEREUX, *Alethopteris lesquereuxi* WAGNER, *Alethopteris kanisi* WAGNER, *Alethopteris grandinioides* var. *subzeilleri* WAGNER, *Pseudomariopteris ribeyroni* (ZEILLER) DANZÉ-CORSIN, *Lobatopteris (Pecopteris) vestita* LESQUEREUX, *Polymorphopteris (Pecopteris) polymorpha* BRONGNIART, and *Pecopteris ocejensis* WAGNER (aff. *arborescens* VON SCHLOTHEIM). These floras are clearly younger than the Ablanedo flora from the central Asturian coalfield. Too little is known of the supposedly lower Stephanian floras of the north-eastern part of the central Asturian coalfield (GARCÍA-LOYGORRI *et al.* 1971)* to allow a detailed comparison with the late Westphalian D floras of north-eastern León and northern Palencia. Basal Stephanian (= Cantabrian) floras are known from disconformable deposits in the Gamonedo-Cabrales area of eastern Asturias (i.e. east of the north-eastern part of the central Asturian coalfield), and it is still conjectural whether the highest beds in the Nalón area of the central Asturian coalfield represent the basal part of these disconformable deposits which show progressive onlap towards the east (MARTÍNEZ-GARCÍA & WAGNER 1971). It is quite certain however, that the highest measures of the central Asturian coalfield are older than the Stephanian A beds of the Barruelo coalfield in north-eastern Palencia (compare WAGNER & WINKLER PRINS 1970).

SYSTEMATIC DESCRIPTIONS

In the following pages a systematic description is presented of the flora of the Olloniego and Esperanza formations sampled by J. PELLO in the general neighbourhood of Olloniego, in the north-western part of the central Asturian coalfield (see text-fig. 1). The occurrence is given by a locality number together with the Catalogue numbers of the specimens deposited in the collection of the Department of Palaeontology in the University of Oviedo.

* Note added when this paper was in press: Dr. GARCÍA-LOYGORRI and his colleagues kindly allowed the present writer to examine their collections of macroflora reputed to be of lower Stephanian age. These collections do not contain any elements which would be exclusively Stephanian in occurrence. They should probably be assigned to the higher part of the Westphalian D.

Neuropteris scheuchzeri HOFFMANN
Pl. 1, figs 2-3; Pl. 7, fig. 1.

1826 *Neuropteris Scheuchzeri* HOFFMANN, *in* KEFERSTEIN, Teutschland geogn.-geol. dargestellt, IV, 2, p.157, Tab. Ib, figs 1-4.

1882 *Neuropteris Scheuchzeri* HOFFMANN ? ZEILLER, Flore houillère des Asturies. pp.6-10.

1952 *Neuropteris scheuchzeri* HOFFMANN - JONGMANS, Documentación flora carbonífera de Asturias, lám. V, figs 18-19[a], lám. VI, fig.20, lám. XXI, fig.66.

1966 *Neuropteris scheuchzeri* HOFFMANN - WAGNER, Palaeobotanical Dating of Upper Carboniferous Folding Phases in NW. Spain, pp. 96-97, pl. 30, figs 67-68a.

1966 *Paripteris scheuchzeri* (HOFFMANN) - STOCKMANS & WILLIÈRE, Documents paléobotaniques du Houiller dans le Nord-Ouest de l'Espagne, pl. VI, fig.8, pl.IX, fig.2, pl.XI, fig.8.

1967 *Neuropteris scheuchzeri* HOFFMANN - LAVEINE, Neuroptéridées du Nord de la France, pp.237-246, pls LXVIII-LXIX. (*N.B.* This paper contains a full list of synonymy).

1969 *Neuropteris scheuchzeri* HOFFMANN - WAGNER, *in* WAGNER, VILLEGAS & FONOLLÁ, LOWER Cantabrian stratotype near Tejerina, p. 127, pl. 3, fig. 11.

1970 *Neuropteris scheuchzeri* HOFFMANN - VAN AMEROM, *in* VAN AMEROM, BLESS & WINKLER PRINS, Upper Carboniferous Sama Formation, p. 26, fig. 4.

1970 *Neuropteris scheuchzeri* HOFFMANN - WAGNER, *in* WAGNER, JONES, SPINNER & WAGNER-GENTIS, Upper Cantabrian near Inguanzo, pp. 471-472, pl. 30, figs 7, 7a.

Material.—Several rather large, detached pinnules which are preserved as impressions on silty mudstone.

Description of the specimens in hand.—Large, acuminate, detached pinnules (up to 10 cm long) showing a moderately dense nervation with a distinct midvein and rather steeply inclined, arching lateral veins which reach the pinnule borders at *ca.* 70°. Fine epidermal hairs cross the veins.

Remarks.—This is one of the most easily identified species, as the result of the characteristic shape of its pinnules and the epidermal hairs crossing over the veins. LAVEINE (1967) interpreted the large pinnules of *N. scheuchzeri* as the retarded, fused equivalent of pinnae of the last order in other neuropterids. It is a fact that these large pinnules are often found together with smaller, orbicular ones, forming a pinna which appears to have its terminal very largely fused. Attention has been drawn by several authors (e.g. LAVEINE 1967) to the odontopteroid characteristics of certain parts of the lobing pinnule (or, as it may be, pinna of the last order) of *Neuropteris scheuchzeri.* In the material at hand no such odontopteroid fragments occur, all specimens being neuropteroid.

The stratigraphic range of *Neuropteris scheuchzeri* in Europe is from upper Westphalian B to upper Cantabrian (compare LAVEINE 1967, p. 246, and WAGNER & VARKER 1971, Table I). In North America it continues beyond the lower Stephan-

ian into strata which are considered to be equivalent to Stephanian B or even Stephanian C (compare DARRAH 1937, p. 121; 1969, p. 13, where *N. scheuchzeri* is quoted in a list of species from the Monongahela Series).

Neuropteris scheuchzeri has been figured several times from Northwest Spain. JONGMANS (1952) illustrated specimens from the Westphalian C and D measures of the central Asturian coalfield, and so does VAN AMEROM (1970). Early records of this species from Asturias were given by ZEILLER (1882), who discussed its synonymy. Lately, WAGNER (1966, 1969) and STOCKMANS & WILLIÈRE (1966) illustrated specimens from late Westphalian D and early lower Stephanian strata in north-eastern León and north-western Palencia. At the top of its stratigraphic range in Northwest Spain, in strata of upper Cantabrian (lower Stephanian *sensu lato*) age, *Neuropteris scheuchzeri* occurs at Peñacorba in the Barruelo Formation of north-eastern Palencia, and at Inguanzo in eastern Asturias (WAGNER *et al.* 1970). A later Stephanian occurrence of *Neuropteris scheuchzeri* was reported by ALVAREZ RAMIS (1966b), but the specimen figured is unconvincing and is probably too poorly preserved to be taken in evidence. Another specimen, reported by DE LA VEGA (1968), cannot be identified with *Neuropteris scheuchzeri* (compare WAGNER *in* WAGNER *et al.* 1970, p. 471).

Occurrence.—Locality 14 (DPO 1100, 1101, 1102, 1103, 1105, 1108, 1112, 1114, 1115, 1125, 1133, 1134, 1137, 1141, 1142, 1146, 1150, 1158, 1161).

Neuropteris cf. *tenuifolia* (VON SCHLOTHEIM) BRONGNIART
Pl. 2, figs. 6, 6a.

1820 *Filicites tenuifolius* VON SCHLOTHEIM, Petrefactenkunde, p. 405, Taf. XXII, fig.1 (*fide* LAVEINE 1967).

1828 *Neuropteris tenuifolia* (VON SCHLOTHEIM) - BRONGNIART, Histoire des végétaux fossiles, pp.241-242, pl.LXXII, figs 3, 3a.

1882 *Neuropteris tenuifolia* (VON SCHLOTHEIM) - ZEILLER, Flore houillère des Asturies, pp.5-6.

1960 *Neuropteris tenuifolia* (VON SCHLOTHEIM) - WAGNER, Middle Westphalian floras from northern Palencia, pp.62-63, figs 6, 7a-d.

1967 *Neuropteris tenuifolia* (VON SCHLOTHEIM) - LAVEINE, Neuroptéridées du Nord de la France, pp.166-176, texte-figs 29a-e, pls XXX-XXXIV.

Material.—Three pinnules forming part of a pinna of the last order (part and counterpart preserved). Preservation in silty mudstone.

Description of the specimen in hand.—Flat rachis of the last order, 1 mm wide, with longitudinal markings. Pinnules almost four times as long as wide (15 mm long, 4 mm wide), with rounded, cordate bases and parallel borders up to two thirds the pinnule length, after which they taper into a bluntly pointed apex. Insertion at point of entry of the midvein which is well marked up to two thirds the pinnule length. Lateral veins very fine, oblique and reaching the pinnule border at *ca.* 45°. There are approximately 30 vein endings per cm on the pinnule border.

Remarks.—The elongate, somewhat acuminate pinnules with blunt apices

are characteristic of *Neuropteris tenuifolia*, and the venation agrees with this identification, even though it should be noted that the veins are not usually as oblique on the pinnule border as they are in the specimen at hand. Since this specimen is also quite fragmentary, and does not show the terminal to a pinna of the last order, it is preferred to record this specimen as *Neuropteris* cf. *tenuifolia* and not to make a straight identification. As LAVEINE (1967) has pointed out, it is sometimes difficult to distinguish pinnules of *N. tenuifolia* from those of *Neuropteris hollandica* STOCKMANS, which are similar in shape and which also possess very fine nervules. In the latter species however, the veins are more widely spaced.

Neuropteris tenuifolia has been recorded by ZEILLER (1882) from three localities in the central Asturian coalfield and by CARIDE & GARCÍA-LOYGORRI (1969) from the Canales and Esperanza formations in the Riosa area of the same coalfield. It has also been described from upper Westphalian B strata in northern Palencia (WAGNER 1960) and from Westphalian B/C boundary measures in northern León (WAGNER, *in* MOORE *et al.* 1971).

Occurrence.—Locality 12 (DPO 1211).

Mixoneura sp. (cf. *peyerimhoffi* P. BERTRAND)
Pl. 2, fig.5; Pl. 5, fig.5.

1930 *Odontopteris (Mixoneura) Peyerimhoffi* P. BERTRAND, Neuroptéridées, pp.49-50, pls XXV-XXVbis.

1957 *Mixoneura peyrimhoffi* P. BERTRAND - JONGMANS & WAGNER, Riosa (Cuenca Central de Asturias), pp.11, 12, 13, 15, 17, 19.

Material.—A small, probably near-terminal fragment of a pinna of the last order preserved in mudstone.

Description of the specimen in hand.—Thin rachis with obliquely inserted, narrowly confluent pinnules showing parallel borders and tapering, though rather blunt apices. Length/breadth ratio approximately 3 : 1 (length up to 7 mm, width 2 mm). Midvein thin, somewhat decurrent at the base. Lateral veins thin, steeply inclined, once to twice forking, and partly derived from the rachis. Approximately 34 veins per cm on the pinnule border.

Remarks.—The specimen described above is too fragmentary to be identified with certainty. The pinnules are rather small but their size could fit that of nearly terminal pinnules in the frond of *Mixoneura peyerimhoffi* as illustrated by P. BERTRAND (1930). The shape and insertion of the pinnules also agree with *M. peyerimhoffi* which is further characterized by the kind of nervation as seen in the specimen at hand. The density of venation appears to be comparable as well.

Mixoneura peyerimhoffi has been recorded from Westphalian C and D strata in the central Asturian coalfield (JONGMANS & WAGNER 1957) and the specimen in hand would merely add to the occurrences quoted. The type specimens, as figured by P. BERTRAND (1930), are from Westphalian D strata in Saar-Lorraine.

Occurrence.—Locality 16 (DPO 1213).

Linopteris obliqua (BUNBURY) ZEILLER

Pl. 1, figs. 1, 1a; Pl. 2, figs. 2-4; Pl. 3, figs. 1, 1a; Pl. 5, fig. 6; Pl. 10, figs. 4, 6; Pl. 17, figs. 2, 2a.

1847 *Dictyopteris obliqua* BUNBURY, Fossil Plants from Cape Breton, pp. 427-428, pl. XXI, figs. 2A-B.

1879/80 *Dictyopteris obliqua* BUNBURY - LESQUEREUX, Coal Flora, pp.146-147, pl. XXIII, figs 4-6.

1882 *Dictyopteris sub-Brongniarti* (*non* GRAND'EURY) - ZEILLER, Flore houillère des Asturies, pp.10-11.

1899 *Linopteris obliqua* (BUNBURY) - ZEILLER, Héraclée, pp.46-48, pl.IV, figs 14-17.

1938 *Linopteris obliqua* (BUNBURY) - BELL, Sydney Coalfield, Nova Scotia, pp.64-65, pl. LVIII, figs 4-5; pl.LX, figs 3-7 (var.*bunburii* BELL).

1951 *Linopteris obliqua* (BUNBURY) - TEIXEIRA, Plantas fósseis do Permo-Carbónico português, II, pp.11-12, Est. XIV, figs 3-6, Est.XV, Est.XVI, figs 2-3, Est. XVII, figs 1-8.

1952 *Linopteris obliqua* (BUNBURY) - JONGMANS, Documentación flora carbonífera de Asturias, pp.10, 11, 12, 13, láms II-IV, VII, XI, XVII, XXI-XXIII, XXVI, XXVIII, figs 3, 3a, 8, 8a, 9, 26, 30, 30a, 52, 52a, 67-68, 73-74, 77, 77a, 86-87a, 90-91a.

1962 *Linopteris obliqua* (BUNBURY) - WAGNER, Upper Westphalian flora from Mina Inés, pp. 82-84, pl. 1, fig. 4, pl. 2, fig. 4a.

1966 *Linopteris obliqua* (BUNBURY) - JOSTEN, Zur Flora des jüngeren Karbons in Nordwestdeutschland, pp. 575-576, Abb. 14, Taf. 10, figs. 3-5, Taf. 11, figs. 1-4.

1967 *Linopteris* cf. *obliqua* (BUNBURY) - LAVEINE, Neuroptéridées du Nord de la France, pp.291-294, texte-figs 49a-b, pl.LXXXIV, figs 1-4.

1970 *Linopteris obliqua* (BUNBURY) - WAGNER, *in* WAGNER & WINKLER PRINS, Cantabrian and Stephanian A rocks at Barruelo, p.514.

Material.—Numerous detached pinnules from several localities.

Description of the specimens in hand.—Rather thick-limbed pinnules of varied size, ranging from 9 to 23 mm length and 3 to 7 mm width; with parallel, almost straight-sided borders, sometimes very slightly subfalcate, and tapering only in the extreme top towards a rounded apex. Venation well marked, with a straight midvein reaching approximately halfway up the pinnule, and arching laterals which are fully anastomosed. Vein meshes variable, rather elongate near the midvein, and becoming more nearly equidimensional near the pinnule borders; thus showing the characteristically wide, almost equidimensional vein meshes most clearly in the smaller pinnules. The meshes are generally about 1 mm long and 0.5 mm wide, but may be up to 2 mm long (or, exceptionally, 2.5 mm). The relatively wide vein meshes form a characteristic feature.

Remarks.—The shape of the pinnules (straight-sided, with parallel borders) and the relatively wide vein meshes form the characteristic features on which *Linopteris obliqua* can be recognized. BELL (1938) distinguished between a type variety and a

var. *bunburii* which would be characterized by straighter pinnules showing somewhat wider vein meshes. The specimens in hand are most similar to the var. *bunburii*, and this may be the result of stratigraphic occurrence, since this variety is reputed to occur in the higher part of the range of *Linopteris obliqua*. The full range of this species is from upper Westphalian B to lower Stephanian, but it characterizes Westphalian C and D.

Linopteris obliqua is probably the most common Carboniferous plant species in the Upper Westphalian of Northwest Spain. It is particularly abundant in the central Asturian coalfield where the productive coal-measures coincide generally with upper Westphalian C and Westphalian D. A good illustration of this species from the central Asturian coalfield has been provided by JONGMANS (1952). It has also been described from Westphalian D strata in the southern part of this coalfield, at the Mina Inés (WAGNER 1962[b]). Its latest occurrence in Northwest Spain, and anywhere in Europe, is in Stephanian A strata of Barruelo (Palencia), where it is very infrequent. In fact, there are only rare occurrences of *Linopteris obliqua* in lower Stephanian strata, and it is true to say that this species mainly characterizes Westphalian C and D (and excluding upper Westphalian D). On the other hand, TEIXEIRA (1951) recorded well preserved material of *Linopteris obliqua* from upper Westphalian D strata in Portugal. The specimens figured as *Linopteris obliqua* by STOCKMANS & WILLIÈRE (1966) do not belong to this species and are partly referable to *Linopteris palentina* WAGNER.

Occurrence.—Locality 10 (DPO 1201, 1202, 1203); Locality 12 (DPO 1210); Locality 13 (DPO 1212); Locality 14 (DPO 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1112, 1113, 1120, 1126, 1127, 1128, 1130, 1132, 1136, 1140, 1145, 1148, 1149, 1151, 1152, 1153, 1154, 1157, 1159, 1164, 1168); Locality 16 (DPO 1214).

Callipteridium (Praecallipteridium) armasi (ZEILLER) WAGNER
Pl.1, fig.5; Pl.2, fig. 1.

1897 *Pecopteris Armasi* ZEILLER, Fougères Asie Mineure, pp. 199-201.

1899 *Pecopteris Armasi* ZEILLER, Héraclée, pp. 35-37, pl. III, figs. 12-16.

1912 *Alethopteris Armasi* (ZEILLER) - FRANKE, Paläozoische Arten von Alethopteris und Callipteridium, pp. 101-105, fig. 1 (specimen from Saar region), figs 2-3 (copies after ZEILLER 1899, pl.III, figs 13, 15) (also *in* H. POTONIÉ 1912, Abb.u.Beschr.foss.Pfl.Reste VIII-160).

1925 *Pecopteris Armasi* ZEILLER - KIDSTON, Fossil Plants, pp.576-579, text-fig.79 (after ZEILLER 1899, pl.III, fig.13), text-fig.80, pl.CXXXV, figs 2, 2a-b.

1932 *Pecopteridium Armasi* (ZEILLER) - P. BERTRAND, Aléthoptéridées, pp.95-97, pl.LIV (new reproductions of specimens figured by ZEILLER 1899, pl.III, figs 13, 15), ?pls LV-LVII, fig.1 (specimens from Saar region).

1939 *Pecopteridium* cf. *Armasi* (ZEILLER) - JONGMANS *et al.*, Karbonflora in Anatolien, p.38, Taf.XI, fig.30.

1961 *Pecopteridium vermeleni* BUISINE, Aléthoptéridées, pp. 272-277, texte-fig. 26, pl.LXXIII.

1963 *Callipteridium (Praecallipteridium) armasi* (ZEILLER) - WAGNER, Les *Callipteridium* du Westphalien supérieur et du Stéphanien, p. 721.

1966 *Callipteridium (Praecallipteridium) armasi* (ZEILLER) - WAGNER, Palaeobotanical Dating of Upper Carboniferous Folding Phases in NW. Spain, pp. 103-106, pl. 17, fig. 37, pl. 18, figs. 38-39, pl. 21, fig. 46.

Material.—A single specimen showing a nearly terminal fragment of a pinna of the last order, imprinted on silty mudstone.

Description of the specimen in hand.—Rachis moderately strong (0.5 mm wide). Pinnule insertion slightly oblique to nearly perpendicular. Pinnules narrowly confluent at the base, and very gradually tapering upwards into a rounded apex. Overall shape of pinnules elongate subtriangular, with a length/breadth ratio varying between 2 and 3 on the average (length 6-12 mm, breadth 2.5-4 mm). Midvein perpendicular, non-decurrent, and fairly strongly marked up to a few mm below the apex. Lateral veins starting at *ca.* 40° from the midvein, and curving fairly rapidly towards a position of *ca.* 80° to the pinnule border (or a little less in the upper parts of pinnules). Subsidiary veins present. Laterals forking once or twice at irregular intervals. Nervation moderately wide (*ca.* 32 veins per cm on the pinnule border).

Remarks.—The specimen described here conforms in all characteristics to *C. armasi* as described from Anatolia, Saar-Lorraine, Britain and Spain. There is also complete agreement with *Callipteridium (Praecallipteridium) vermeleni* (BUISINE) WAGNER, as described from lower Westphalian D strata of northern France. Although BUISINE (1961, p.271) mentioned having compared with the various species of «*Pecopteridium*» (= *Praecallipteridium*) from the Westphalian D of Saar-Lorraine (as figured by P. BERTRAND 1932), there was no discussion of the differences observed between *C. vermeleni* and *C. armasi*. BUISINE (1961, p.276) did compare in detail with *Callipteridium (Praecallipteridium) jongmansi* (P. BERTRAND) WAGNER, which has a denser venation. According to BUISINE (1961), *C. vermeleni* (= *C. armasi*) may be distinguished from *Callipteridium (Praecallipteridium) lerati* (BUISINE) WAGNER by its stronger midvein and less widely spaced nervules.

The reasons for replacing *Pecopteridium* P. BERTRAND (*non* FONTAINE & WHITE) by *Praecallipteridium* and for regarding this taxononic unit as belonging to *Callipteridium* WEISS, have been given in 1963. It is noted that both *C. vermeleni* and *C. armasi* have had specimens recorded which show the presence of axillary basal catadromous pinnules on the rachides of the penultimate order in the lower parts of pinnae. The presence of a few intercalated pinnules in the top part of pinnae of the penultimate order has been shown for *C. armasi* from Anatolia.

Although *C. armasi* has been recorded rarely in the literature, it is not too uncommon in Northwest Spain where it has been found in strata reputed to be of upper Westphalian D age (WAGNER 1966, p. 28; WAGNER 1967, p. 49; WAGNER & VARKER 1971). The inclusion of *C. vermeleni* in the synonymy of this species adds a lower Westphalian D record. All the other records in the literature appear to relate to upper Westphalian D strata.

Occurrence.—Locality 10 (DPO 1207).

Alethopteris grandinioides KESSLER var. *grandinioides*
Pl.1, figs 1-2, 4; Pl.3, figs 1, 1a.

1916 *Alethopteris Grandinoides* KESSLER, Alethopteriden und Mariopteriden der Saarbrücker Schichten, p. 76, Taf. IX, figs. 3, 3a.

1966 Indéterminé STOCKMANS & WILLIÈRE, Documents paléobotaniques pour l'étude du Houiller dans le Nord-Ouest de l'Espagne, pl.X, figs 5-6a.

1967 *Alethopteris grandinioides* KESSLER - WAGNER, Floras de la zona de Gamonedo-Cabrales, p.49, lám.I, fig.4.

1968 *Alethopteris grandinioides* KESSLER var.*grandinioides* - WAGNER, Upper Westphalian and Stephanian species of Alethopteris, pp.72-80, text-figs 14-16, pls 18-23. (With a full synonymy up to 1966).

1969 *Alethopteris grandinioides* KESSLER - WAGNER *in* WAGNER, VILLEGAS & FONOLLÁ, Description of Lower Cantabrian stratotype near Tejerina, p. 126, pl. 4, figs 16, 16a.

M a t e r i a l.—About thirty fragments of pinnae of the last order, some of which show the terminal. Preservation as imprints on silty mudstone.

D e s c r i p t i o n o f t h e s p e c i m e n s i n h a n d.—Pinnae of the last order gradually tapering into a lanceolate terminal. Rachides of the last order striate, up to 1.2 mm thick. Pinnules variable in size (length 5-20 mm, width 3-7 mm), with a length/breadth ratio varying between 2 and 3 on the average, characteristically ribbon-shaped, with parallel to slightly convex borders and a broadly rounded apex. Pinnules generally broadly confluent, but narrowly confluent or pecopteroid in the lower parts of pinnae. Midvein distinct to well marked up to approximately two thirds of the pinnule length, beyond which it dissolves into lateral veins. Nervules broadly arching, rather widely spaced (*ca.* 22 veins per cm on the pinnule border), starting at a very acute angle from the midvein and reaching the pinnule border at *ca.* 60° to 80°. Subsidiary veins present on both the basiscopic and the acroscopic sides.

R e m a r k s.—The robust looking pinnules with a broadly rounded apex and widely spaced, broadly arching veins, are fully characteristic of the type variety of *Alethopteris grandinioides* KESSLER. The large size of most of the pinnules found provides the reason for a generally more nearly perpendicular attitude of the veinlets to the pinnule border than is usual for *A. grandinioides* var. *grandinioides*. The wide spacing of the veinlets provides an argument in favour of the type variety rather than *A. grandinioides* var. *subzeilleri* WAGNER which shows some 35 veins per cm on the pinnule border.

The list of synonymy reproduced here supplements the one published in WAGNER 1968, which deals with this species monographically. It is noted that the var. *subzeilleri* becomes individualized from upper Westphalian D onwards, whereas the type variety of *A. grandinioides* ranges from upper Westphalian B to lower Stephanian (middle Cantabrian). It is essentially an Upper Westphalian alethopterid. The var. *subzeilleri* effects the passage from *A. grandinioides* var. *grandinioides* to *Alethopteris zeilleri* RAGOT (= *A. grandini* ZEILLER, *non* BRONGNIART).

Occurrence.—Locality 14 (DPO 1101, 1102, 1103, 1104, 1106, 1108, 1109, 1110, 1111, 1112, 1113, 1129, 1130, 1131, 1132, 1142, 1144, 1145, 1147, 1148, 1149, 1150, 1153, 1157, 1158, 1159, 1161); Locality 15 (DPO 1171, 1175, 1176, 1177, 1188, 1195).

Mariopteris (Fortopteris) latifolia (*non* BRONGNIART?) ZEILLER
Pl. 4, figs. 1, 1a-b; Pl. 5, figs. 3-4a; Pl. 6, figs. 1, 1a; Pl. 17, figs. 3, 3a.

1879 *Mariopteris latifolia* (BRONGNIART) - ZEILLER, Note sur le genre *Mariopteris*, p.98, pl.VI.

1882 *Mariopteris latifolia* (BRONGNIART) - ZEILLER, Flore houillère des Asturies, p. 5.

1886/88 *Mariopteris latifolia* (BRONGNIART) - ZEILLER, Valenciennes, pp.161-164, pl.XVII, figs 1-2, pl.XVIII, fig.4.

1899 *Sphenopteris* sp. D. WHITE, Lower Coal Measures of Missouri, pl.XLV, figs 2, 2a.

1910 *Mariopteris latifolia* (BRONGNIART) - RENIER *et al.*, Paléontologie du Terrain houiller, pl.86, figs a-b.

1925 *Mariopteris latifolia* (BRONGNIART) - KIDSTON, Fossil Plants, 6, pp.643-648, text-figs 94-95 (after ZEILLER 1886, pl.XVII, fig.1), pl. CXLIV, fig.7 (fragmentary but probably correctly identified).

1932 *Mariopteris latifolia* (BRONGNIART) - CORSIN, Guide paléontologique, pl. XXVIII, figs 1, 1a.

1935 *Mariopteris latifolia* (BRONGNIART) - GOTHAN, Steinkohlenflora der westlichen paralischen Steinkohlenreviere Deutschlands, pp.32-34, Taf.35, figs 2, 4 (fragmentary specimens).

1938 *Mariopteris latifolia* (BRONGNIART) - BELL, Sydney Coalfield, Nova Scotia, pp.49-50, pl. XXXIX, figs 2-4 (fragmentary specimens).

1951 *Mariopteris latifolia* (BRONGNIART) - JONGMANS, Sud-Oranais, pp.9, 13, pl.I, fig.10 (fragment).

1953 *Mariopteris latifolia* ZEILLER - DANZÉ-CORSIN, Marioptéridées, pp. 230-239, pls LXXIII-LXXVI.

1955 *Mariopteris latifolia* (BRONGNIART) - DABER, Pflanzengeographische Besonderheiten des Zwickau-Lugauer Steinkohlenreviers, p.17, Taf.6, fig.4 (fragmentary).

1957 *Mariopteris latifolia* (BRONGNIART) - DABER, Parallelisierung Zwickau und Lugau-Oelsnitz, pp.60-62, Abb.9-11.

1957 *Mariopteris latifolia* ZEILLER - DANZÉ-CORSIN, Découverte d'échantillons fructifiés appartenant au genre Mariopteris, pp.181-183 (description, without illustration, of the probable microsporangiate organ of *M. latifolia*).

1960 *Mariopteris latifolia* (BRONGNIART) - RADFORTH & WALTON, Fossil Plants from Minto Coalfield, New Brunswick, p.106, pl.4, fig.14 (mentioned as *Mariopteris* cf. *latifolia* in plate explanation).

1962 *Mariopteris latifolia* (BRONGNIART) - BELL, Pictou Group of New Brunswick, pp.25-26, pl. XIII, fig.3, pl.XIV, fig.2, pl.XV, figs 1-2, pl.XVI, fig.2.

1969 *Fortopteris latifolia* (ZEILLER) - BOERSMA, A Fertile leaf of «Mariopteris latifolia», pp.65-69, text-figs 1-2, pls 1-4.

M a t e r i a l.—Six pinna fragments, one of which shows two successive dichotomies of the frond; preservation as imprints in brownish weathering silty mudstone.

D e s c r i p t i o n o f t h e m a t e r i a l i n h a n d.—Principal specimen (Pl.4, figs 1, 1a-b) showing a striate rachis of the first order (R_1), 2.5 mm wide, dichotomizing under a wide angle (150°) into two striate rachides (R_2), 2 mm wide, which after a 15 mm interval dichotomize again under a wide angle (130°) into longitudinally grooved flexuous rachides of the third order (R_3), 1.5 mm wide. The latter possess alternating pinnae of the last order, which are inserted almost perpendicularly and which are 25 to 40 mm long on the specimen in hand. Pinnae of the last order characterized by a longitudinally grooved rachis, 0.4 to 0.8 mm wide, and a gradually tapering outline with a small terminal produced by gradually fusing pinnules. Pinnules inserted somewhat obliquely, contracted near the base in the lower parts of pinnae, and not contracted at all in the upper parts of pinnae. They are very characteristically united at the base by a narrow strip of limb along the rachis in the case of the lower pinnules, and are broadly confluent in the case of the upper pinnules. Basal pinnules often bilobate. Pinnules shallowly lobed, generally ovoid in outline, with rounded lobes. Pinnule margin shallowly denticulate (as visible on well preserved specimens only), with blunt teeth which receive the ends of lateral veins. Limb moderately thick, but not, perhaps, quite as thick as in most species of *Mariopteris*. Midvein decurrent, rather thin, and dissolving into laterals at approximately halfway the pinnule length. Lateral veins starting from the midvein at an acute angle (30° to 40° approximately), and dichotomizing up to three times before reaching the pinnule margin obliquely. Nervation rather wide (*ca.* 20 veins per cm on the pinnule margin).

R e m a r k s.—This is one of the most characteristic species of *Mariopteris* which is distinguished immediately by the relatively thin, supple, flexuous (almost zig-zagging) rachides which are grooved and which thus mark this species as belonging to the major division of the *Alineae* P. DANZÉ-CORSIN. In DANZÉ-CORSIN'S detailed description of *Mariopteris latifolia* it is pointed out that the only comparable species is *Mariopteris leharlei* CORSIN, another member of the *Alineae*, which shows a less wide angle of bifurcation of the rachides (*ca.* 90°) and a slightly different shape and nervation of the pinnules. These differences are slight and *Mariopteris leharlei*, possibly an endemic species from Saar-Lorraine, has been figured repeatedly as *Mariopteris latifolia* from the Saar-Lorraine coalfield (e.g. LUTZ 1938).

This species was originally described as *Sphenopteris latifolia* by BRONGNIART (1830, pp. 205-206, pl. 57, figs 1-4). It is possible that the later illustrations of *Mariopteris latifolia* do correspond to BRONGNIART'S species, but, as CORSIN (1932) and DANZÉ-CORSIN (1953) have pointed out, the diagrammatic drawings published by BRONGNIART preclude an exact identification. DANZÉ-CORSIN therefore prefers

to regard the specimens figured by ZEILLER (1879, 1886) as the effective types, and even refers to this species as *Mariopteris latifolia* ZEILLER.

The material in hand is undoubtedly conspecific with *Mariopteris latifolia sensu* ZEILLER, and its characteristics coincide fully with the description of this species as given by DANZÉ-CORSIN. Particularly important is the wide angle of forking of the main rachis or petiole (R_1), and this is shown very well by the specimen figured on Pl.4, figs 1, 1a, b, which represents the basal part of a small frond.

There is no sign on the specimens in hand of the small dots between veins which have been reported by BODE (1928) and DABER (1957) as secretory cells or druse cells. RADFORTH & WALTON (1960) recorded fungal attack on leaves of *Mariopteris latifolia* from North America (Canada).

DANZÉ-CORSIN (1957) reported finding probable pollen sacs projecting beyond the limb of recognizable pinnules of *Mariopteris latifolia*. No illustrations were given by DANZÉ-CORSIN, but fertile specimens of *M. latifolia* were figured and more fully described by BOERSMA (1969), who regarded the fructification as a probable fern synangium. He concluded that *Mariopteris latifolia* had to be separated from the presumed pteridosperm genus *Mariopteris*, and instituted the genus *Fortopteris* for *M. latifolia* and, apparently, the other species included by DANZÉ-CORSIN in the *Alineae*. It may be right to erect a genus to receive the *Alineae*, and in this sense *Fortopteris* may well be allowed to stand. On the other hand, the diagnosis of this genus has been closely linked to the fructification which, in the absence of fertile specimens of other *Mariopteris*, may well tend to restrict *Fortopteris* permanently to *M. latifolia*. It is also not quite certain that BOERSMA'S interpretation of the fructification of *M. latifolia* as being a fern synangium will prove to be correct. The possibility that this fructification is, in fact, a microsporangiate (pollen bearing) organ cannot be excluded, and the link with *Mariopteris sensu stricto* may be stronger than BOERSMA suggests.

Mariopteris (Fortopteris) latifolia is widely distributed in Europe and also occurs in North America. Its stratigraphic range, according to DANZÉ-CORSIN (1953), is from upper Westphalian B to lower Westphalian D (i.e admitting the upper part of the Assise de Bruay in northern France as lower Westphalian D), with a maximum of occurrence in the higher measures. A Westphalian D age is confirmed by DABER (1955, 1957), and Westphalian C and D occurrences are reported from North America by BELL (1938, 1962). The specimen figured by D. WHITE (1899, pl. XLV, figs 2, 2a), which is here assigned to *M. latifolia*, may have come from strata of a similar age. *Mariopteris latifolia* was mentioned from Ciaño, in the central Asturian coalfield, by ZEILLER (1882), who also noted that this species had been recorded previously from San Juan de las Abadesas (prov. Gerona) in N. E. Spain. Since the latter locality is well known for its Upper Stephanian flora, this record of *M. latifolia* may well be doubted.

Occurrence.—Locality 15 (DPO 1172, 1173, 1174, 1176, 1184, 1187, 1189, 1190, 1192, 1195, 1215).

Dicksonites potieri (ZEILLER) P. BERTRAND
Pl.5, figs 1-2a.

1886/88 *Sphenopteris Potieri* ZEILLER, Valenciennes, pp. 88-90, pl. XIV, figs. 1, 1A.
1913 *Dicksonites Potieri* (ZEILLER) - P. BERTRAND, Liste provisoire des Sphenopteris du Nord de la France, p. 311.
1924 *Telangium (?) Potieri* (ZEILLER) - KIDSTON, Fossil Plants, 5, pp. 461-463, pl. CII, figs. 2-4.
1937 *Dicksonites irregularis (non* STERNBERG) - NĚMEJC, Sphenopterides in the Permocarboniferous of Bohemia, II, p.11, fig.5 (*non* pl.fig. 13 (= lectotype of *Sphenopteris irregularis* STERNBERG pro parte, NĚMEJC emend.).
1951 *Dicksonites potieri* (ZEILLER) - NĚMEJC & ŠETLÍK, Suite des recherches dans les districts houillers de la Bohême, p. 78.
? 1952 *Dicksonites geishecki* GUTHÖRL, Leit-Fossilien und Stratigraphie des saar-lothringischen Karbons, p.237, pl.12, figs 5-6.
? 1957 *Dicksonites geishecki* GUTHÖRL, Querschnitt durch das saar-lothringische Karbon, 4, p.31, Taf.8, fig.5, Taf. 11, fig.3.
1957 *Sphenopteris* cf. *potieri* ZEILLER - JONGMANS & WAGNER, Riosa (Cuenca Central de Asturias), pp.15, 17.

Material.—Four fragments of pinnae of the penultimate and last orders preserved as impressions and compressions on silty mudstones.

Description of the material in hand.—Rachides fairly strong (up to 1 mm wide) and rounded, with longitudinal grooves on the broader ones. Pinnules variable in size and lobing gradually, with angular lobes. Insertion of the pinnules only slightly oblique. Pinnules either fused at the base or linked by a narrow strip of limb along the rachis between adjacent pinnules. The limb appears rather stiff. Midvein a little decurrent at the base and strongly marked. Lateral veins departing at *ca.* 60° and dichotomizing in a radiating pattern, each bundle of veins corresponding to a pinnule lobe. Nervation fairly wide.

Remarks.—The remains described above are fragmentary, but they resemble on all counts the specimens noted in the list of synonymy. The most complete specimen recorded is that figured by ZEILLER (1886). Some of the pinnae of the penultimate order found in this specimen are identical in the shape and size of pinnules to the fragment figured on Pl. 5, figs. 2, 2a of the present paper. The variation in size and degree of lobing of the pinnules is further illustrated by the specimen figured on Pl. 5, figs 1, 1a, which probably represents a nearly terminal portion of a pinna of the last order. It shows very clearly the thin strip of limb along the rachis, which is mentioned in ZEILLER's description of *Sphenopteris potieri.*

P. BERTRAND (1913) remarked upon the resemblance between this species and *Dicksonites sterzeli* (ZEILLER) and referred *S. potieri* to STERZEL's genus *Dicksonites.* An even more striking resemblance exists with *Dicksonites leptophylla* ZEILLER.

KIDSTON (1924) discussed the microsporangia of *Dicksonites potieri* after a specimen in the collection of P. BERTRAND. He expressed some doubt as to the correct attribution of this specimen to *Telangium*.

In a revision of sphenopterids from Bohemia, NĚMEJC (1937) indicated that *Dicksonites potieri* (ZEILLER) was a synonym of *Sphenopteris irregularis* STERNBERG (pro parte) and figured both the lectotype of this species and a specimen which appears to be very similar to *D. potieri*. In a later paper by NĚMEJC & ŠETLÍK (1951) the synonymy between *Sphenopteris irregularis* and *Dicksonites potieri* is not maintained, and it seems likely that the lectotype of *S. irregularis* belongs to a different species than the specimen figured by NĚMEJC (1937, fig. 5) as *Dicksonites irregularis*. The latter is here included in the synonymy of *Dicksonites potieri*.

It appears probable that *Dicksonites geishecki* GUTHÖRL should be regarded as a synonym of *Dicksonites potieri*. GUTHÖRL's species was founded on two specimens which could well fit the known variation within the frond of *D. potieri*. GUTHÖRL's description is brief and he fails to compare with other species. It may be necessary to examine the type specimens of *D. geishecki* before the synonymy with *D. potieri* can be regarded as fully established, however.

The species discussed here is generally rare, but apparently rather widely distributed geographically. The records from northern France, Bohemia, Saar-Lorraine and England seem to indicate a stratigraphic range from Westphalian C to lower Westphalian D. Two records from Northwest Spain (JONGMANS & WAGNER 1957) extend this range to middle Westphalian D (Ablanedo near Riosa in the north-western part of the central Asturian coalfield — specimens re-examined by the present writer).

Occurrence.—Locality 10 (DPO 1201, 1204); Locality 14 (DPO 1167 — cf. *potieri*); Locality 15 (DPO 1175, 1189, 1196).

Alloiopteris cristata (VON GUTBIER) NĚMEJC
Pl.7, figs 1-2a; Pl.8, figs 3, 3a.

1843 *Pecopteris (Diplazites) cristatus* VON GUTBIER, Gaea von Sachsen, p.80 (*fide* DANZÉ 1956).

1938 *Alloiopteris cristata* (VON GUTBIER-GEINITZ) - NĚMEJC, Sphenopterides, Coenopteridae, pp. 22, 46, text-fig. 9e, pl. I, fig. 10, pl. III, fig. 13.

1955 *Saccopteris cristata* (VON GUTBIER) - DABER, Pflanzengeographische Besonderheiten des Zwickau-Lugauer Steinkohlenreviers, p.23, Taf.VII, figs 4, 4a.

1956 *Corynepteris* cf. *cristata* (VON GUTBIER) - DANZÉ, Les fougères sphénoptéridiennes, pp.346-347, pl. LVII, figs 3, 3a.

1959 *Alloiopteris cristata* (VON GUTBIER) - REMY, Pflanzenfossilien, p.140, Abb.113.

Material.—Nine specimens showing fragments of pinnae of the penultimate order imprinted on silty mudstone.

Description of the specimens in hand.—Rachides of the penultimate order relatively thin (up to 1 mm wide) and rounded. Pinnae of the last order inserted perpendicularly; pinnae tapering gradually towards an acute apex. Rachides of the last order very thin (*ca.* 0.2 mm) and rounded. Pinnules obliquely inserted and confluent, though generally quite separate, with deep sinusses between adjacent pinnules. Limb apparently rather thin. Pinnules characteristically plano-concave on the basiscopic, decurrent border, and cristate on the convex, forward facing border which shows generally two to four pointed teeth. Pinnules up to twice as long as wide (*ca.* 2 mm long, 1 mm wide). Midvein decurrent and dichotomizing quite near the base, with one or two further dichotomies taking place higher up the pinnule. Each vein ending corresponds to a tooth on the cristate border.

Remarks.—The relatively well individualized pinnules with an asymmetrical development of the cristate border distinguish this species from *Alloiopteris erosa* (VON GUTBIER) WHITE, which has more broadly confluent pinnules with generally three, rather less elongate teeth on the distal border. The degree of confluence of the pinnules naturally varies with the position within the pinnae, and the larger pinnules lower down the pinnae are more nearly separate than those found in the upper parts of pinnae. In the specimens in hand some of the pinnules at the base of the pinnae of the last order are almost completely individualized, and it seems that they are likely to be more individualized in *Alloiopteris cristata* than they are in equivalent parts of the frond of *Alloiopteris erosa.* It is also noted that the pinnules of *A. cristata* may become more slender in aspect than those of *A. erosa,* which are more nearly equidimensional. The incisions on the border of the pinnules of *A. cristata* also appear to be deeper and its teeth correspondingly longer than those of *A. erosa.*

Alloiopteris cristata can be distinguished from *Alloiopteris angustissima* (STERNBERG) STOCKMANS & WILLIÈRE by noting its thinner rachides and generally larger, less equidimensional pinnules. The rachides of *A. angustissima* (= *Alloiopteris sternbergi* VON ETTINGSHAUSEN) are extremely stout in relation to the very small pinnules.

It should be noted that the specimens in hand show smaller pinnules than those described from *A. cristata* by NĚMEJC (1938), who mentioned 4 mm length and 2 mm width for the pinnules of this species. However, the length/breadth ratio is correct for the specimens in hand, which also coincide with *A. cristata* in the other characteristics. A specimen of *A. cristata* showing pinnules of comparable size to the ones figured in the present paper, appears in REMY'S «Pflanzenfossilien», and this seems to confirm the identification.

Alloiopteris cristata has been figured only rarely, but is known from the Westphalian D of Zwickau in Saxony, and of central Bohemia (Plzeň), and from the Westphalian C of northern France. The material reported in the present paper adds another Westphalian D occurrence for this species which had not, thus far, been recorded from Northwest Spain.

Occurrence.—Locality 14 (DPO 1106, 1114, 1128, 1133, 1140, 1141, 1150, 1159, 1166, 1168).

Alloiopteris erosa (VON GUTBIER) D. WHITE
Pl. 8, figs 4, 4a.

1843 *Pecopteris erosa* VON GUTBIER, Gaea von Sachsen, p. 81 (*fide* DANZÉ 1956).
1899 *Alloiopteris erosa* (VON GUTBIER)-D. WHITE, Lower Coal Measures of Missouri, pp. 70-71, pl. XXIII, fig. 6, pl. XXIV, fig. 3a.
1955 *Saccopteris (Corynepteris) erosa* (VON GUTBIER) - DABER, Pflanzengeographische Besonderheiten des Zwickau-Lugauer Steinkohlenreviers, pp. 22-23, Abb. 4, Taf. VI, figs. 2, 5.
1956 *Corynepteris erosa* (VON GUTBIER) - DANZÉ, Les fougères sphénoptéridiennes, pp. 341-346, pl. LVI, figs. 1-4a, pl. LVII, figs. 1, 1a.
1966 *Alloiopteris erosa* (VON GUTBIER) - WAGNER, Palaeobotanical Dating of Upper Carboniferous Folding Phases in NW. Spain, pp.124-125, pl.17, fig.36, pl.25, fig.52.

Material.—Two fragments of pinnae of the penultimate order, imprinted on silty mudstone.

Description of the specimens in hand.—Slender, faintly grooved rachides of the penultimate order with side pinnae inserted almost at right angles. Pinnae of the last order gradually tapering towards an acute apex. Rachides of the last order moderately sturdy and rounded. Pinnules confluent up to one half or two thirds of the pinnule length or more clearly individualized, with the sinus between adjacent pinnules extending downwards to near the rachis. Insertion oblique. Pinnules nearly equidimensional (1.5-2 mm long, 1.5 mm wide), with a straight to concave lateral border on the basiscopic side, and a more convex forward directed side. The latter, together with the distal border, is split into lobes with pointed teeth, usually two or three in number. Midvein decurrent and dichotomizing once or twice into laterals which end into the teeth on the distal and acroscopic borders.

Remarks.—The specimens in hand are quite similar to those belonging to *Alloiopteris cristata* (VON GUTBIER), but for the nearly equidimensional pinnules and a general tendency for the pinnules to be more largely confluent. There is a particularly good comparison with *Corynepteris (Sphenopteris) erosa* as figured by DANZÉ (1956, pl.LVI, figs 1, 1a).

Alloiopteris erosa occurs throughout the Westphalian in Europe and North America. It has been recorded previously from Northwest Spain (WAGNER 1966), from strata of late Westphalian D age.

Occurrence.—Locality 15 (DPO 1178, 1197).

Sphenopteris pelloi sp.nov.
Pl.8, fig.2; Pl.9, figs 1, 1a.

1957 *Sphenopteris obtusiloba* (*non* BRONGNIART) - GUTHÖRL, Querschnitt durch das saar-lothringische Karbon, 4, p.6, Taf.4, figs 2a-b.

Holotype.—Fragment of a pinna of the penultimate order figured on Pl.9, figs 1, 1a. Type locality at Malpica, near Olloniego (Asturias), in the upper part of the Olloniego Formation; Westphalian D; PELLO loc.14. *Repository*: Department of Palaeontology, University of Oviedo (DPO 1125).

Derivatio nominis.—Named after J. PELLO, of the University of Oviedo (Asturias).

Diagnosis.—Closely packed, vaulted pinnules with rounded to subangular lobes (generally 3 to 5 lobes per pinnule with a length/breadth ratio of 1.5 to 2) which are not as well individualized as in *S. obtusiloba*. Pinnae gradually tapering, with elongate terminals.

Description.—Thin (1-1.5 mm wide), slightly flexuous rachides of the penultimate order showing faint longitudinal grooves. Pinnae of the last order rather widely spaced, inserted at angles varying from 60° to 90°, and tapering very gradually into a thin, elongate terminal. Rachides of the last order thin (*ca.* 0.5 mm wide), rounded, and fairly straight. Pinnules vaulted, closely spaced and even slightly overlapping. Insertion variable and ranging from a stalked base to partial fusion with the rachis, depending on the position within the pinna. Fully developed pinnules quintulobate, a little less than twice as long as wide (*ca.* 6-7 mm long, 3.5-4 mm wide), stalked, with rounded to subangular lobes showing entire margins; lobes not fully individualized. Smaller, less fully developed pinnules trilobate to entire, more nearly equidimensional (*ca.* 4 mm long, 3 mm wide), stalked to more broadly based, with rounded to subangular lobes largely adherent to the pinnule. Pinnule insertion changing from almost perpendicular in the lower parts of pinnae to more oblique in the upper parts. Midvein stout at the base and distinctly marked up to one half to two thirds of the pinnule length. Lateral veins given off alternately, at an oblique angle, and dichotomizing generally twice, sometimes three times in order to form the vein bundles servicing the pinnule lobes. Nervation fairly wide and oblique to the pinnule margin.

Comparisons.—*Sphenopteris obtusiloba* BRONGNIART is distinguished by its more individualized lobes in trilobate and quintulobate pinnules; otherwise the resemblance with *Sphenopteris pelloi* is quite close. *Sphenopteris neuropteroides* (BOULAY) shows the more shallow clefts between lobes which also characterize *S. pelloi*, but possesses generally squatter pinnules with a more clearly expressed tendency for partial fusion of the pinnule bases with the rachis. It is noted that *S. pelloi* appears somewhat intermediate in characteristics between *S. obtusiloba* and *S. neuropteroides*, its pinnules being relatively broader and more rounded than those of *S. obtusiloba* and somewhat less rounded than those of *S. neuropteroides*. The insertion of the pinnules and the degree of individualization of the pinnule lobes reinforce the impression of intermediate characteristics.

Remarks.—Only one figured specimen in the literature seems to coincide in all respects with *Sphenopteris pelloi* sp.nov. This is a well preserved fragment of a pinna of the penultimate order which has been figured as *Sphenopteris obtusiloba* BRONGNIART by GUTHÖRL (1957) and which originated from the Geisheck Schichten (basal Westphalian D) of the Saar region. It is noted that GOTHAN & REMY (1957)

record *Sphenopteris obtusiloba* as a plant which is particularly common in Westphalian A and B strata, but which ranges into Westphalian C. *Sphenopteris pelloi* occurs a little higher, in Westphalian D, and one might speculate on the possibility that this is the successor to *S. obtusiloba*. On the other hand, *Sphenopteris rotundiloba* NĚMEJC, which also resembles *S. obtusiloba* quite closely, occurs in Stephanian strata. *S. rotundiloba* shows generally well individualized lobes, and it may be that *S. obtusiloba*, at the end of its range (Westphalian C), split into varieties showing more and less well individualized lobes respectively. However, this is still a matter for speculation.

Sphenopteris neuropteroides (BOULAY) is noted by GOTHAN & REMY (1957) as ranging throughout Westphalian C and D. Good specimens of *S. neuropteroides* have been figured from the central Asturian coalfield by JONGMANS 1952 (as *Pecopteris pluckeneti* and cf. *Sphenopteris nummularia)* and ALVAREZ RAMIS (1966[a]) adds a record from Stephanian B strata. *S. neuropteroides* has since been found in upper Westphalian D strata of northern Palencia (WAGNER & VARKER 1971) and Stephanian A-B strata of the Sabero coalfield (KNIGHT 1971).

Besides the holotype of *Sphenopteris pelloi* sp. nov. (Pl. 9, figs. 1, 1a) a small fragment is figured from the type locality, showing the insertion of pinnules and the fairly wide venation (Pl.8, fig.2).

Occurrence.—Locality 14 (DPO 1102, 1125, 1126, 1162).

Sphenopteris nummularia VON GUTBIER
Pl.6, figs 2, 2a; Pl.9, figs 2, 2a.

1835-36 *Sphenopteris nummularia* VON GUTBIER, Zwickauer Schwarzkohlen, pp. 43-44, Taf. IV, fig. 5, 5 a-c, Taf. X, figs 7-8, Taf. XI, fig. 3.

1923 *Sphenopteris nummularia* VON GUTBIER - KIDSTON, Fossil Plants, 1, pp.38-41, pl.IV, figs 1-2 (3?), pl.V, figs 4, 4a, pl.VII, figs 2-4a.

1929 *Sphenopteris nummularia* VON GUTBIER- GOTHAN, Steinkohlenflora der westlichen paralischen Carbonreviere Deutschlands, pp. 31-32, Taf. IV, fig. 1.

1932 *Sphenopteris nummularia* VON GUTBIER - CORSIN, Guide paléontologique, pl.XXXII, figs 2-3.

1952 *Sphenopteris nummularia* VON GUTBIER - GUTHÖRL, Leitfossilien und Stratigraphie des saar-lothringischen Karbons, pl. 12, fig. 9.

1955 *Sphenopteris nummularia* VON GUTBIER - DABER, Pflanzengeographische Besonderheiten der Karbonflora des Zwickau-Lugauer Steinkohlenreviers, p. 7, Taf. XV, figs. 1-2.

1959 *Sphenopteris nummularia* VON GUTBIER - REMY, Pflanzenfossilien, p. 130, Abb. 97.

1962 *Sphenopteris nummularia* VON GUTBIER - BARTHEL, Epidermisuntersuchungen, p.12, Taf.IV, fig.2, Taf.V, figs 2, 4-6.

Material.—A fragment of a pinna of the penultimate order belonging probably to the lower part of a tripinnate element; and two other, more nearly terminal fragments of pinnae of the penultimate order; all preserved as imprints on silty mudstone.

Description of the specimens in hand.—Moderately thin (1 mm wide) rachis of the penultimate order with side pinnae (of the last order) inserted at a wide angle (*ca.*70° to 80°). Rachides of the last order fairly sturdy (up to 0.8 mm wide), without distinguishing features. Pinnules oblique to the rachis, stalked to partially fused with the rachis, entire to trilobate, and generally equidimensional. Lobes rounded to subangular. Limb strongly convex. Nervation indistinct.

Remarks.—The range of entire to trilobate pinnules is fairly characteristic of *Sphenopteris nummularia*, the lobing pinnules of which tend to develop into pinnae of the last order by the full individualization of lobes when the quintulobate stage is reached. The pinnules and lobes of this species are strongly convex, this feature being the result of a compression border as described by WALTON (1936, p.225, fig.4). The size and shape of the pinnules and lobes in the specimen at hand correspond fully to figured, undoubted examples of *S. nummularia*, e.g. Abb.97 in REMY 1959, which reproduces a specimen of equivalent position in the frond.

The list of synonymy given in the present paper only states some of the most characteristic among the fairly numerous figured specimens of *Sphenopteris nummularia*. Not all the material recorded as *S. nummularia* belongs to this species. For example, the specimens figured as cf. *Sphenopteris nummularia* by JONGMANS (1952, lám.IX, figs 31, 31a, lám.XI, figs 31d-e) from the central Asturian coalfield, are to be assigned to *Sphenopteris neuropteroides* (BOULAY) (compare WAGNER 1959[b], p. 404). Conversely, material attributed to the somewhat similar species *Sphenopteris obtusiloba* BRONGNIART is sometimes referable to *Sphenopteris nummularia* (e.g. TEIXEIRA 1940, Est.V, figs 3-4, Est.VI, figs 1-3). Species similar to *S. nummularia*, but characterized by smaller pinnules and lobes are *Sphenopteris bradfordii* ARNOLD and *Sphenopteris marrati* KIDSTON.

According to REMY (1959, p.130), *Sphenopteris nummularia* ranges from upper Westphalian B to Westphalian D. Specimens which are extremely similar to *Sphenopteris nummularia*, but perhaps not fully identical to this species, have been recorded as *Sphenopteris* sp. nov.? (aff. *nummularia* VON GUTBIER) from the lower Cantabrian (early lower Stephanian *sensu lato*) of Tejerina (León) by WAGNER *in* WAGNER, VILLEGAS & FONOLLÁ (1969, p.121). An even later occurrence, from lower Stephanian B strata, is reported by STOCKMANS & WILLIÈRE (1966, pl. XXI, figs. 4, 4a), but the specimen figured by these authors should probably be identified as *Sphenopteris rotundiloba* NĚMEJC.

Occurrence.—Locality 10 (DPO 1205); Locality 14 (DPO 1160).

Sphenopteris chaerophylloides (BRONGNIART) PRESL
Pl.10, figs 2, 2a.

1835 *Pecopteris chaerophylloides* BRONGNIART, Histoire des végétaux fossiles, pp.357-358, pl.125, figs 1-2.

1838 *Sphenopteris chaerophylloides* (BRONGNIART) - PRESL, *in* STERNBERG, Versuch geogn.bot.Darstellung Flora der Vorwelt, II, fasc.VII-VIII, p.131.

1885 *Hapalopteris typica* STUR, Farne der Schatzlarer Schichten, pp.46-49, Taf. XLII, figs 3-4.

1923 *Renaultia chaerophylloides* (BRONGNIART) - KIDSTON, Fossil Plants, 4, pp.315-317, pl. LXXVIII, figs 3-4a.

1956 *Renaultia chaerophylloides* (BRONGNIART) - DANZÉ, Les fougères sphénoptéridiennes, pp.194-199, texte-figs 12a-d.

Material.—A fragment of a pinna of the penultimate order preserved as an imprint on silty mudstone.

Description of the specimen in hand.—Rachis of the penultimate order thin (0.3 mm wide), rounded and flexuous. Rachides of the last order thin and rounded. Lobing pinnules in the top part of the pinna are obliquely inserted and confluent by a narrow strip of limb along the rachis. Passage to pinnae of the last order effected at septilobate stage. Insertion of pinnae almost perpendicular. Lobes pointed and often divided into shallowly cleft pointed segments. Limb thin and nervation poorly visible. Midvein very thin, and obliquely inserted. Lateral veins very thin, widely spaced, and dichotomizing at least once.

Remarks.—The specimen in hand, though fragmentary, appears entirely comparable to the figuration of *Renaultia chaerophylloides* presented by KIDSTON (1923) and DANZÉ (1956), and the identification has been made accordingly. According to DANZÉ, this species ranges from Westphalian B to Westphalian C, but higher occurrences are reported in the literature, even from Stephanian strata.

Occurrence.—Locality 10 (DPO 1201).

Sphenopteris opulenta DANZÉ
Pl.10, figs 1, 1a.

1956 *Discopteris (Sphenopteris) opulenta* DANZÉ, Les fougères sphénoptéridiennes, pp.267-272, texte-figs 22a-c, pls XIX-XX, pl.XXI, figs 1-6.

Material.—Two fragments of pinnae imprinted on silty mudstone.

Description of the specimen in hand.—Very thin rachides (0.2 mm wide) with a strip of limb along the rachis joining adjacent pinnules which are contracted at the base but not stalked. Pinnules with angular, bluntly denticulate lobes. Limb apparently rather thin, with the veins shallowly imprinted. Midvein thin, decurrent and flexuous. Lateral veins equally thin, widely spaced, and generally once or twice forked.

Remarks.—Despite the fragmentary nature of the specimen in hand, there is no reason to doubt the identification with *Sphenopteris opulenta* which is well characterized by its relatively large pinnules (in comparison with the similar species *Sphenopteris chaerophylloides* BRONGNIART), the winged rachides, and the thinly limbed pinnules with angular lobes showing occasional blunt teeth. The thin, widely spaced veins are also characteristic. The two pinna fragments of the specimen in hand

can be matched without hesitation with certain parts of the pinnae figured by DANZÉ (1956).

This is the first record of *S. opulenta* outside the type area in northern France, where it was reported from the Assise de Bruay, i.e. from Westphalian C and lower Westphalian D strata. DANZÉ mentioned that *Sphenopteris opulenta* appeared fairly frequently, with probably a maximum of occurrence at the base of the Assise de Bruay.

Occurrence.—Locality 15 (DPO 1185).

Sphenopteris cf. *amoena* (STUR) KIDSTON
Pl.8, figs 1, 1a.

1885 *Hapalopteris amoena* STUR, Farne der Schatzlarer Schichten, pp.52-54, Taf.XLI, figs 7, 7a.

1934 *Sturia amoena* (STUR) - NĚMEJC, On two new Sphenopteris fructifications, pp.2-3, pl.figs 1-6.

1941 *Sphenopteris (?Renaultia) amoena* (STUR) - GOTHAN, Steinkohlenflora der westlichen paralischen Steinkohlenreviere Deutschlands, 4, pp.29-31, Taf.60, figs 1, 4.

1956 *Sturia amoena* (STUR) - DANZÉ, Les fougères sphénoptéridiennes, pp. 370-376, texte-figs 33a-d, pl.LXXII, figs 4, 4a, pl.LXXIII.

Material.—Four fragments of pinnae, relatively poorly preserved as impressions on silty mudstone.

Description of the specimens in hand.—Thin, rounded rachides of the penultimate and last orders. Pinnae of the last order inserted at approximately 60°. Pinnules small, *ca.* 2 mm long on the average, and only a little longer than they are wide; pinnule base usually contracted but partially fused with the rachis, and not stalked; limb rather thin. Pinnules lobed and ranging from almost entire, with undulate margins, to septilobate; lobes apparently blunt or split into blunt segments. Nervation poorly preserved, but apparently consisting of a thin midvein and widely spaced, dichotomizing laterals.

Remarks.—Although the specimens in hand show the shape and size of pinnules recorded for *Sphenopteris amoena*, and correspond in all the visible characteristics with this species, they are not considered well enough preserved to be referred to it without hesitation. DANZÉ has provided the most exhaustive and accurate description of *S. amoena*, which he figured after some exquisitely preserved specimens. In discussing the synonymy of this species, he remarked upon *Sphenopteris bella* (STUR), *S. schilleri* GOTHAN and *S. amoenaeformis* KIDSTON being all referable to *Sphenopteris amoena.*

This species has been recorded throughout the Westphalian.

Occurrence.—Locality 14 (DPO 1165).

Sphenopteris cf. *sewardi* KIDSTON
Pl.10, figs 3, 3a.

1923 *Sphenopteris Sewardi* KIDSTON, Fossil Plants, 2, pp.136-138, pl. XXVIII, figs 2-3.

1956 *Sphenopteris Sewardi* KIDSTON - DANZÉ, Les fougères sphénoptéridiennes, pp.496-500, texte-figs 59a-c, pl. LXXXII, fig.2.

Material.—A small terminal fragment of a pinna of the last order, preserved in silty mudstone.

Description of the specimen in hand.—A thin, rounded rachis with obliquely inserted pinnules which are linked at the base by a thin strip of limb along the rachis. Pinnules constricted near the base, and up to septilobate in the specimen at hand. Lobes elongate and bluntly pointed. Pinnules fairly slender, with apical growth, up to a little over twice as long as wide in the specimen available (4-5 mm long, 2 mm wide). Midvein well marked, slightly decurrent at the base, and persisting upwards into the top of the pinnule. Lateral veins given off alternately, at *ca.* 50° from the midvein, widely spaced, and either single or once dichotomizing in the lobes.

Remarks.—The specimen in hand compares well to figures provided by DANZÉ (1956) of a specimen from the Westphalian C-D boundary measures of northern France. The comparison with KIDSTON's original type from the upper Westphalian D Radstockian of Somerset, England, is also quite reasonable, although it is noted that the diagram on his pl. XXVIII, figs. 2a-b, shows rather more pointed lobes than seem to characterize the specimen in hand. The latter is too small a fragment to allow a definite identification.

Occurrence.—Locality 10 (DPO 1205).

Palmatopteris membranacea (VON GUTBIER) STERZEL
Pl.10, fig.5.

1835 *Sphenopteris membranacea* VON GUTBIER, Zwickauer Schwarzkohlen, pp.35-36, Taf. XI, fig. 2.

1901 *Palmatopteris (Diplotmema) membranacea* (VON GUTBIER) - STERZEL, Paläontologischer Charakter der Steinkohlenformation und des Rothliegenden von Zwickau, p.94.

1923 *Diplotmema Duponti* STUR- KIDSTON, Fossil Plants, 3, pp. 262-264, pl. LXIII, figs 1-2.

1955 *Palmatopteris membranacea* (VON GUTBIER) - DABER, Pflanzengeographische Besonderheiten des Zwickau-Lugauer Steinkohlenreviers, p.14, Taf.II, figs 2, 2a.

Material.—A terminal fragment of a pinna imprinted on silty mudstone.

Description of the specimen in hand.—Rachis longitudinally grooved, up to 0.5 mm wide, with pinnules inserted obliquely. Terminal elongate, almost tendril-like. Pinnules up to quintulobate, with oblique cuneate lobes subdivided

into bluntly pointed segments. Pinnules generally stalked, relatively spreading (palmate), equidimensional to approximately twice as long as wide. Midvein well marked. Lateral veins very oblique and usually dichotomizing more than once.

Remarks.—The specimen in hand, though fragmentary, can be identified without difficulty with *Palmatopteris membranacea* as figured by DABER (1955). This species is characterized by its spreading limb, as against the more digitate pinnules of *Palmatopteris furcata* (BRONGNIART). Its relatively small pinnules are also less markedly elongate than those of *Palmatopteris sturi* GOTHAN.

There appears to be identity between *Palmatopteris membranacea* (VON GUTBIER) and *Palmatopteris duponti* (STUR), as figured by KIDSTON (1923). With the original description of the latter STUR (1885, p.319) mentioned that the specimens of his *Diplothmema Duponti* had come to him labelled *Sphenopteris furcata* and *Sphenopteris membranacea*. No comparison was made with *P. membranacea* however, possibly because of the diagrammatic illustrations of this species available at that time. KIDSTON (1911, p.21) united *Diplothmema Gilkineti* STUR with *D. Duponti* STUR.

The total range of *Palmatopteris membranacea* (and including *P. duponti*) may be from Westphalian B to Westphalian D.

Occurrence.—Locality 14 (DPO 1170).

Pecopteris unita BRONGNIART
Pl.11, figs 5, 5a; Pl. 17, figs 1, 1a, 3, 3a.

1836 *Pecopteris unita* BRONGNIART, Histoire des végétaux fossiles, p.342, pl.116, figs 1-5.

1925 *Ptychocarpus unitus* (BRONGNIART) - KIDSTON, Fossil Plants, 6, pp.548-554, pl.CXXXI, figs 1-9a. (With a full synonymy).

1938 *Ptychocarpus unitus* (BRONGNIART) - BELL, Sydney Coalfield, Nova Scotia, p. 77, pl. LXXII, fig. 2, pl. LXXIII, figs. 4-6.

1941 *Pecopteris unita* BRONGNIART - GOTHAN, Steinkohlenflora der westlichen paralischen Steinkohlenreviere Deutschlands, 4, pp. 50-51, Taf. 71, fig. 4.

1951 *Pecopteris unita* BRONGNIART - CORSIN, Pécoptéridées, pp. 350-353, text-figs. 95 A-D, pl. CLXXX, figs. 2, 2a (? figs. 1, 1a-b, 3, 3a-b), *non* pl. CXC (= *Lobatopteris* sp.), pl. CXCI, figs 1-2, *non* figs 3, 3a.

1957 *Ptychocarpus unitus* (BRONGNIART) - GUTHÖRL, Querschnitt durch das saarlothringische Karbon, 4, p. 49, Taf. 11, figs. 5a-b.

1966 *Pecopteris unita* BRONGNIART - WAGNER, Palaeobotanical Dating of Upper Carboniferous Folding Phases in NW. Spain, pp. 28, 29, 40, 50, 52, 54, 55, 56, 58, 60, 61, 63, 69, 73, 75, 79, 129, 130, 132, pl. 19, fig. 41.

1966 *Pecopteris unita* BRONGNIART - STOCKMANS & WILLIÈRE, Documents paléobotaniques du Houiller dans le Nord-Ouest de l'Espagne, pl.XVIII, figs 4, 4a, pl.XXVI, figs 2, 2a.

1966 *Pecopteris unita* BRONGNIART - JOSTEN, Flora des jüngeren Karbons in

Nordwestdeutschland, p.569, Abb.3, Taf.4, fig.3, *non* Taf.5, figs 1, 1a (= *Pecopteris* cf. *camertonensis* KIDSTON).

Material.—Three fragments of pinnae of the last order preserved as imprints on silty mudstone.

Description of the specimens in hand.—Pinnae of the last order tapering into a fused terminal with a blunt, rounded apex. Rachis of the last order very thin (0.2-0.3 mm). Pinnules largely fused (up to approximately half the pinnule length), decurrent on the rachis, very slightly tapering in the top part, with a rounded apex. They are approximately twice as long as wide (4 mm long, 2 mm wide). Midvein decurrent and lateral veins single, widely spaced, curved upwards and partly overlapping. Elongate epidermal cell pattern visible on one specimen. Limb convex.

Remarks.—The specimens in hand correspond entirely to *Pecopteris unita* as figured by BRONGNIART (1836). It is noted that the pinnules of *P. unita* tend to become more fully united as higher levels of the Upper Carboniferous are reached. At the same time the lateral veins become more extensively overlapping. In these respects the specimens described here are standard *Pecopteris unita*, in the lower part of its range.

The «unitoid» venation of a decurrent midvein and curved, overlapping, single laterals is also found in the lobing stages of pecopterids of the *Lobatopteris* group, and there are several examples in the literature where these lobing fragments have been identified as *Pecopteris unita* BRONGNIART. Other species showing a «unitoid» venation and extensively fused pinnules, often with the apices of pinnules forming the undulate border of almost totally fused pinnae, are either late variants of *Pecopteris unita* or separate species. These forms appear generally in Stephanian B strata and continue into the Permian. They have been described under the generic name of *Validopteris* P. BERTRAND by STOCKMANS & MATHIEU, and this usage has been continued provisionallly by the present writer (WAGNER 1962[a], pl. 31 - explanation of «*Validopteris*» *hispanica* WAGNER), even though it is noted that the original diagnosis of *Validopteris* is based on lobing fragments of *Alethopteris* and *Lobatopteris* (WAGNER 1968, pp.29-30). A full taxonomic revision of «*Validopteris*» STOCKMANS & MATHIEU (*non* P. BERTRAND), in conjunction with *Pecopteris unita* BRONGNIART, is long overdue.

The stratigraphic range of *Pecopteris unita* is quoted by CORSIN (1951, p.353) as upper Westphalian D to Stephanian, and the infrequent records of this species from earlier Westphalian strata are rejected by this author. However, the specimen figured by GOTHAN (1941, Taf.71, fig.4), from late Westphalian C (or early Westphalian D?) strata at Ibbenbüren, is a perfectly reasonable example of *Pecopteris unita* BRONGNIART. Another specimen from probably early Westphalian D strata in Germany was figured by JOSTEN (1966, Taf.4, fig.3). The earliest Spanish occurrence of this species has been given as *Pecopteris* cf. *unita* by JONGMANS & WAGNER (1957, p.12) from rocks in the Canales Formation which are regarded as early Westphalian D. The specimen in question is not at present accessible to the present writer, but several other specimens recorded as *Pecopteris* cf. *unita* by JONGMANS & WAGNER (1957, p. 16) have been

re-examined and belong certainly to this species. These were collected from the Ablanedo Formation in the Riosa area of the central Asturian coalfield, which is presently regarded as approximately middle Westphalian D in age. Although *Pecopteris unita* thus appears to commence its occurrence in strata at least as early as lower Westphalian D, it is rather uncommon up to the level of upper Westphalian D where it is more frequently encountered. It is one of the most common species found in Stephanian strata. Records from upper Westphalian D and lower Stephanian strata in Northwest Spain have been given by WAGNER (1966) and STOCKMANS & WILLIÈRE (1966), who also report this species from later Stephanian rocks.

Pecopteris unita was reported as common in the Radstockian of the Bristol/Somerset area in England (middle to upper Westphalian D) and rare in the Staffordian (Westphalian C-lower Westphalian D) (KIDSTON 1925).

Occurrence.—Locality 15 (DPO 1179, 1180, 1184, 1186).

Pecopteris cf. *obliquenervis* CORSIN
Pl.12, figs 1-2a.

1925 *Pecopteris integra (non* ANDRAE) - KIDSTON, Fossil Plants, 6, pp.579-581, pl.CXXXVII, figs 4, 4a.

1951 *Pecopteris obliquenervis* CORSIN, Pécoptéridées, pp.353-354, texte-fig.96, pl.CXCVII, figs 3, 3a.

? 1951 *Pecopteris* cf. *arborescens (non* VON SCHLOTHEIM) - JONGMANS, Sud-Oranais, pp.20-22, pl.XIII, figs 113a, b.

? 1951 *Pecopteris* cf. *oreopteridia* (*non* VON SCHLOTHEIM) - JONGMANS, Sud-Oranais, pp.20-22, pl.XIII, fig.117.

? 1959 *Pecopteris obliquenervis* CORSIN - REMY, W. & R., Pflanzenfossilien, p.153, Abb.130.

Material.—Approximately thirty pinna fragments, some of which show the terminal. The nervation of these impressions is poorly preserved.

Description of the material in hand.—Pinnae of the last order tapering very gradually into an elongate terminal. Rachis very thin. Pinnules obliquely inserted on the rachis, broadly confluent, and subtriangular in shape with rounded apices. Length/breadth ratio varies from 1.5 to 3 (length 3-6 mm, width *ca.* 2 mm). Limb very thin. Midvein thin and markedly decurrent. Lateral veins widely spaced, generally simple but sometimes forked once.

Remarks.—The specimen on which CORSIN (1951) based his *Pecopteris obliquenervis*, shows pinnae of the last order which are quite comparable to the specimens in hand, although it is noted that his nervation diagram shows a higher incidence of forked veins than seems to be present in the material described here. CORSIN also mentions the poor preservation of the venation which may be due to a thin limb. The size, shape and insertion of the pinnules and the shape of the terminal agree between

the type and the specimens in hand, and it is only the paucity of forked lateral veins which apparently distinguishes the material described here.

CORSIN mentioned the similarity between *Pecopteris obliquenervis* and *Pecopteris unita* BRONGNIART, a resemblance which is even more striking with the specimens discussed here, since these show predominantly simple veins. However, in *Pecopteris unita* the lateral veins are curved and, in so far as visible on the specimens in hand, they are more or less straight in *Pecopteris* cf. *obliquenervis*.

This species has been described from the Assise de la Houve, zone de Forbach, i.e. lower Westphalian D, and appears to be rare (one specimen only). REMY (1959) identified as *Pecopteris obliquenervis* a specimen from the Upper Stephanian of Germany, which shows curved lateral veins in a more closely spaced arrangement than that indicated by the type. This specimen may well have to be excluded from the synonymy.

Both KIDSTON (1925) and JONGMANS (1951) figured specimens comparable to *Pecopteris obliquenervis* under different names. JONGMANS' material is probably not well enough preserved to be specifically identifiable (as he indicated himself), but the specimen figured by KIDSTON is better preserved and may be assigned to *Pecopteris obliquenervis*. It came from Westphalian D strata in South Wales.

Occurrence.—Locality 14 (DPO 1113, 1115, 1116, 1130, 1137, 1139, 1140, 1142, 1143, 1144, 1147, 1149, 1150, 1152, 1154, 1156, 1157, 1158, 1162, 1166).

Lobatopteris serpentigera WAGNER
Pl.4, fig.1; Pl.11, figs 1-4.

1951 *Pecopteris waltoni* CORSIN (pro parte), Pécoptéridées, pp.301-303 (pro parte), texte-fig.B, pl. CLXI, figs 3-4.

1959 *Pecopteris (Lobatopteris) serpentigera* WAGNER, Some Stephanian Pecopterids, pp.19-21, text-fig.12, pl.12, figs 30, 30a.

Description.—Rachis of the penultimate order fairly thin (1 mm wide), with faint longitudinal striations. Pinnae of the last order characterized by blunt, broadly rounded terminals, subsequent to gradually fusing pinnules. Rachides of the last order rather thin (less than 0.5 mm wide) and flexible. Pinnules broadly confluent, obliquely inserted, with subparallel margins and a broadly rounded apex. Length/breadth ratio of pinnules 1.5 to 2 (3 to 7 mm long, 2 to 3 mm wide). Size of pinnules somewhat irregularly distributed within pinnae, with a tendency for the basal catadromous pinnule to be rather more strongly developed. Midvein thin and decurrent even in the longer pinnules. Lateral veins thin, very widely spaced (*ca.*15 veins per cm on the pinnule border), oblique, partly simple in the small, largely fused pinnules of lobing parts of the frond, but more commonly once bifurcate, the dichotomy taking place at a variable distance from the midvein (though apparently never at the midvein itself). Fructification unknown.

Remarks.—The description given above takes into account not only the specimens figured in the present paper (practically all that has been found this time) but also the holotype as figured in 1959. The latter represents a lobing part of the frond with rather small, incompletely developed pinnules showing a nervation characterized by generally simple nervules. The additional material reproduced here increases the knowledge of *Lobatopteris serpentigera* by showing a lobing fragment with more individualized pinnules (Pl. 11, figs 2, 2a) and three fragments of pinnae with more fully developed pinnules (Pl. 11, figs 1, 1a, 3-4). The nervation in the more fully individualized pinnules shows the common occurrence of once bifurcate veins. It is noted that the degree of fusion between the bases of adjacent pinnules diminishes with an increasing length/breadth ratio. Even the most fully individualized pinnules of Pl. 11, figs 1, 1a, however, show the presence of a thin strip of lamina connecting adjacent pinnules. This specimen contains at least one pinnule with slightly undulate borders which are indicative of the beginning of gradual lobing. It thus shows the longest kind of fully developed, non-lobing pinnules occurring in *Lobatopteris serpentigera.*

It was emphasized in 1959 that this species resembled to a large extent *Lobatopteris aspidioides* (STERNBERG) WAGNER, which was refigured in the same paper. The latter apparently differed only in the denser arrangement of its lateral veins. The additional material of *Lobatopteris serpentigera*, reported in the present paper, allows the observation that the fully developed pinnules of this species are apparently more obliquely inserted than those of *Lobatopteris aspidioides*. The similarities between the two species are undoubtedly close.

A specimen figured by CORSIN (1951, pl.CLXI, figs 3-4) under the name of *Pecopteris waltoni* CORSIN, was attributed to *Pecopteris (Lobatopteris) serpentigera* by WAGNER (1959). It shows identical characteristics to those found in the specimen figured on Pl.11, figs 2, 2a, of the present paper.

The holotype of *Lobatopteris serpentigera*, showing a lobing part of the frond, offered only a limited scope for comparison. This may be the reason why STOCKMANS & WILLIÈRE (1966, pl. XXVII, figs. 11, 11a) figured a lobing terminal to a pinna of the penultimate order under the name of *Pecopteris serpentigera* WAGNER, whereas this specimen probably belongs to a different species of *Lobatopteris*. Lobing fragments are notoriously difficult to identify.

Stratigraphic distribution.—The holotype came from Stephanian A measures (Calero Member of the Barruelo Formation) of the Barruelo coalfield in north-eastern Palencia (NW Spain). Additional specimens were mentioned but not figured from the Stephanian B of Ciñera-Matallana (León, Spain) and the Stephanian C of Villablino (León, Spain) and from the Rotliegendes of Ilfeld in Germany (WAGNER 1959, pp.20-21). CORSIN's (1951) specimen came from the Mines of Petite-Rosselle in Lorraine. The specimens recorded in the present paper add a Westphalian D occurrence to this species which may be ranging from Westphalian D into basal Permian (or uppermost Stephanian).

Occurrence.—Locality 15 (DPO 1172, 1188, 1191, 1196).

Pecopteris (Asterotheca) miltoni (ARTIS) BRONGNIART
Pl.12, fig. 3; Pl.13, fig 1-3a.

1825 *Filicites Miltoni* ARTIS, Antediluvian Phytology, pl.XIV (with description).
1834 *Pecopteris Miltoni* (ARTIS) - BRONGNIART, Prodrome, p. 58.
1885 *Hawlea Miltoni* (ARTIS) - STUR, Farne der Schatzlarer Schichten, pp. 108-120, Taf. LIX, figs 1-4, Taf. LX, fig. 2 (*non* figs 1, 3-4?).
1913 *Pecopteris (Asterotheca) Miltoni* (ARTIS) - GOTHAN, Oberschlesische Steinkohlenflora, pp.154-157, Taf. 35, figs 1-3.
1924 *Asterotheca Miltoni* (ARTIS) - KIDSTON, Fossil Plants, 5, pp. 501-516, pl. CXX, figs. 1-5, pl. CXXI, figs. 1, 3 (*non* figs. 2,4), *non* pl. CXXII.
? 1928 *Pecopteris (Asterotheca) Miltoni* (ARTIS) - ŠUSTA, Ostrau-Karviner Steinkohlenrevier, Taf. XXX, Abb. 2, Taf. XXXII, Abb. 6, Taf. XXXIII. Abb. 1.
1941 *Pecopteris (Asterotheca) Miltoni* (ARTIS) - GOTHAN, Steinkohlenflora der westlichen paralischen Steinkohlenreviere Deutschlands, 4, pp. 48-49, Taf. 68, *non* Taf. 67, figs. 1-2 (= *Pecopteris lobulata* DALINVAL).
1957 *Pecopteris miltoni* (ARTIS) - GOTHAN & REMY, Steinkohlenpflanzen, p.114, Abb.107.
1957 *Pecopteris (Asterotheca) Miltoni* (ARTIS) - STOPA, Fougères de la Haute Silésie, pp.79-80, 190, pl.XXIX, figs 1-2.
1959 *Pecopteris miltoni* (ARTIS) - W. & R. REMY, Pflanzenfossilien, p.148, Abb.122.
1960 *Pecopteris (Asterotheca) Miltoni* (ARTIS) - DALINVAL, Pecopteris du Nord de la France, pp.133-149, pls XXXII-XXXIII, XXXVI, ?*non* pls XXXIV-XXXV, XXXVII-XL.

Material.—Fifteen fragments of pinnae of the last and penultimate orders, preserved as weathered imprints on silty mudstone. Both the sterile foliage and pinnules with synangia are present.

Description of the material in hand.—Pinnae of the penultimate order gradually tapering, with fairly slender apices. Pinnae of the last order inserted at a wide angle, and characterized by a small, rounded, well individualized terminal. Rachides of the penultimate order relatively strong (up to 7 mm wide in the specimen figured on Pl.13, fig.1), apparently rather flat, and irregularly grooved. Rachides of the last order generally *ca.* 0.5 mm wide, with irregular, rather indistinct longitudinal markings. Pinnules variable in shape, lobing gradually, with the smallest individualized units broadly attached and even somewhat confluent. Lobing pinnules still broadly attached to the rachis but becoming constricted at the base at the transition to pinnae of the last order. Pinnules parallel sided, with a broadly rounded apex. They are not too closely spaced however, and some of the pinnules tend to a bluntly subtriangular shape. Pinnule size varies from 3-8 mm length and 2-2.5 mm width (non-lobing) to 9-10 mm length and 2.5-3 mm width (lobing pinnules), the length/breadth ratio changing markedly throughout the pinnae. Midvein distinct, though not excessively strong, dissolving before the pinnule apex. Lateral veins widely spaced

(*ca.* 20 per cm?), generally once forked, but dichotomizing at least once more in the larger, lobing pinnules. Nervation indistinctly preserved. Fructifications poorly preserved, but apparently synangia of the *Asterotheca* type which seem to be positioned nearer the pinnule margin than the midvein, on the underside of the lamina.

Remarks.—The drawing of ARTIS' type specimen of *Pecopteris miltoni* shows several features in common with the specimens in hand, viz. the extremely sturdy rachides of the penultimate order, the size and shape of the pinnules and, particularly, the small and rounded apical pinnules to the pinnae of the last order. Also, the fructifications are shown to be rather small and tending towards a position nearer to the pinnule margin than the midvein. All these characteristics seem to confirm the identification of the specimens in hand. However, it has been noted in the literature that the type specimen of *Pecopteris miltoni* is no longer available for direct comparison, and this imposes an element of doubt which is not dispelled by the subsequent figuration of this species by the various authors.

The type specimen having originated from the Yorkshire coalfield in Britain, the additional specimens figured by KIDSTON (1924) are of considerable importance. Unfortunately, his specimens from the Yorkshire coalfield are fragmentary and do not show the variation of pinnae and pinnules within the frond. The more complete specimens which he figured from the Radstockian of Somerset, are probably not to be included with *Pecopteris miltoni* (ARTIS). The specimen figured on KIDSTON's Pl. CXXI, figs 2, 2a has been referred to *Pecopteris punctata* CORSIN by CORSIN (1951, p. 289) and to *Pecopteris acadica* BELL by BELL (1962, p.31). The latter is closely similar to both *Lobatopteris lamuriana* (HEER) and *Lobatopteris vestita* (LESQUEREUX). The other specimens figured by KIDSTON from the Somerset area are mainly referable to a precursor of *Lobatopteris lamuriana* which the present writer has identified with *Lobatopteris vestita* (LESQUEREUX) and which may, perhaps, also be compared with *Pecopteris abbreviata* BRONGNIART (pro parte). The question of the correct identity of *Pecopteris abbreviata*, a species which is usually treated as synonymous with *Pecopteris miltoni*, can only be solved by a direct comparison with BRONGNIART's type specimens.

BELL (1962, p. 31) has pointed out that *Pecopteris abbreviata*, as figured by ZEILLER (1886, Pl. XXV), differs from *Pecopteris miltoni* most markedly because of its elongate, slender pinnae, as against the more abruptly terminated pinnae of the latter. ZEILLER's material, which may or may not be correctly identified with the majority of BRONGNIART's types of *Pecopteris abbreviata*, has been assigned to *Pecopteris miltoni* by KIDSTON (1924), CORSIN (1951) and DALINVAL (1960). The specimens figured by DALINVAL from the North of France, and which he assigns to *Pecopteris miltoni*, show a considerable variation in the shape of the terminals which are much more elongate for the pinnae of the penultimate order than for those of the last order. On the whole, however, they do not appear to be quite as abruptly terminated as is suggested by the drawing of the type *Pecopteris miltoni* published by ARTIS. Some of the specimens figured by DALINVAL are so different as to be most unlike the type (compare list of synonymy). Also the specimens figured and described as *Pecopteris miltoni* by CORSIN (1951) appear to be rather different from the type.

Pecopteris miltoni is one of the most commonly quoted elements of Westphalian flora, and the «Fossilium Catalogus» contains several pages of records referring to this species. Only a small selection of the most important and most reliable records containing figured specimens, has been reproduced in the present paper. They show it to occur in Westphalian strata. GOTHAN & REMY (1957) mention its range as from upper Westphalian A to middle Westphalian D, with doubtful later occurrences.

This is the first time that *Pecopteris miltoni* (ARTIS) has been figured from Northwest Spain. Older records, as quoted by DE LA VEGA (1959, p.54), may be difficult to substantiate. The specimen mentioned by JONGMANS & WAGNER (1957, p.17) from (middle) Westphalian D strata at Ablanedo (Riosa, Asturias), is most comparable to material figured by DALINVAL (1960) from the Westphalian of northern France.

Occurrence.—Locality 14 (DPO 1108, 1115, 1117, 1118, 1119, 1120, 1121, 1122, 1123, 1124, 1135, 1136, 1161, 1167, 1169).

Pecopteris (Asterotheca) punctata CORSIN
Pl.14, figs 1-6; Pl.15, figs 1-4; Pl.16, fig.1a.

1951 *Pecopteris punctata* CORSIN, Pécoptéridées, pp.261-264, texte-fig.61, pls CXLIII-CXLIV.

? 1960 *Pecopteris* aff. *punctata* CORSIN - JONGMANS, Karbonflora der Schweiz, p.76, Taf.38, figs 192, 192a.

1967 *Pecopteris (Asterotheca)* cf. *punctata* CORSIN - WAGNER, Floras de Gamonedo-Cabrales en Asturias, pp.51, 52, 54, lám.III, fig.11.

Material.—Eighteen fragments of pinnae of the last order, several of which are fertile. Two specimens show the terminal.

Description of the material in hand.—Pinnae of the last order gradually tapering into a rather small, pointed terminal. Rachides apparently smooth or with tiny irregularities, rounded and relatively thin (less than 0.5 mm wide). Pinnules generally non-lobing, almost perpendicular to the rachis, parallel sided with a rounded apex, mainly two to three times as long as wide (*ca.*5-8 mm long, 2-2.5 mm wide), with a decurrent basiscopic side and a slightly constricted acroscopic side. Well preserved specimens show a thin strip linking adjacent pinnules which are sometimes rather closely packed and sometimes more widely spaced. Limb sturdy and convex, thus preventing often the preservation of the detail of basal attachment, with the result that the pinnules appear generally constricted at the base. Midvein prominent but failing to reach the apex of the pinnules. Lateral veins widely spaced (*ca.* 17 veins per cm on the pinnule border), oblique and generally forking once at a short distance from the midvein; the upper branch of the forking veins sometimes (rarely) divides again. Fructification of the *Asterotheca* type, with four sporangia forming a large synangium covering almost the entire space between the midvein and the pinnule margin.

Remarks.—The size and shape of the pinnules, their convex limb, the nervation, and the shape of the terminal all coincide with the characters shown by the types. The name of the species refers to scattered points on the underside of the pinnules, marking the bases of hairs (CORSIN 1951). This feature has not been seen on the specimens in hand which may not be well enough preserved in this respect. CORSIN also mentioned hairs on the rachides of the very well preserved specimens from Saar-Lorraine, and this characteristic is also not clearly visible on the specimens described here. The somewhat decurrent midvein mentioned by CORSIN is visible on some of the specimens in hand, but the preservation of the basal part of the pinnules is often defective, thus preventing this feature from being clearly visible on the majority of specimens.

The fructification of *Pecopteris punctata* was mentioned as being of the *Asterotheca* type, when describing some less well preserved material from eastern Asturias (WAGNER 1967), and the material in hand confirms this.

CORSIN (1951) described *Pecopteris punctata* as being found throughout the Assise de la Houve (Westphalian D) of Saar-Lorraine, where it is reputed to be not too rare. A record from the lower Stephanian of Switzerland (JONGMANS 1960) refers to poorly preserved specimens. The material recorded as *Pecopteris* cf. *punctata* from eastern Asturias (WAGNER 1967), is probably assigned correctly to this species. It came from strata which are either late Westphalian D or basal Stephanian (lower Cantabrian) in age.

Occurrence.—Locality 15 (DPO 1174, 1175, 1176, 1177, 1179, 1180, 1181, 1182, 1183, 1184, 1185, 1186, 1188, 1193, 1194, 1195, 1196, 1215).

Sphenophyllum orbiculare REMY
Pl.16, figs 1-2a.

1962 *Sphenophyllum orbicularis* REMY, *Sphenophyllum* aus dem Karbon des Saargebietes, pp.242-245, Abb.4-5, Taf.4, figs 4-8.

Material.—Five fragments of leaf whorls on four rock specimens.

Description of the material in hand.—Leaves variable in size but approximately as long as wide on the distal border (dimensions: 18 mm length at 20 mm width; 15 mm/14 mm; 14 mm/14 mm; 18 mm/14 mm; 9 mm/5 mm). Lateral borders straight, distal border with central cleft reaching down to about halfway the length of the leaf; additional clefts not nearly as deep. Number of teeth on distal border approximately 32 for the specimen measuring 18 mm length and 20 mm width. Teeth pointed triangular with possibly excurrent veins. Apparently, a single vein enters the leaf and divides immediately.

Remarks.—REMY (1962) revised *Sphenophyllum majus* BRONN and described two new species which had been included with *S. majus sensu lato*. One of these species, *Sphenophyllum orbiculare* REMY, was noted as being characterized by relatively broad leaves (approximately as wide as long), showing pointed triangular

teeth on the distal border. A central cleft reaching down to about halfway the length of the leaf was also mentioned. A special point was made about the veins being excurrent and slightly expanded before leaving the distal teeth. The triangular shape of the latter was contrasted with the gothic arch shape of the teeth on the distal border of *Sphenophyllum majus (sensu stricto)*, which also possesses leaves with a 1.5 : 1 or 2 : 1 length/breadth ratio.

The specimens in hand correspond on all counts to *Sphenophyllum orbiculare*. It is noted however that the preservation needs to be extremely good in order to see clearly the shape of the distal teeth, and it is only in one or two places that the shape of the teeth is clearly visible on the specimens in hand.

Sphenophyllum orbiculare has only been recorded once from upper Westphalian D strata in the Saar coalfield (REMY 1962). The present writer has recently had an opportunity to collect this species again from these Heiligenwalder Schichten, during an excursion led by Dr. G. KNEUPER. The specimens described here constitute the first record outside the type area.

Occurrence.—Locality 15 (DPO 1185, 1193, 1194, 1198, 1199, 1200).

Sphenophyllum trichomatosum STUR
Pl. 16, figs 3, 3a.

1887 *Sphenophyllum trichomatosum* STUR, Calamarien der Schatzlarer Schichten, pp. 202-205, Taf. XV, figs. 1,4 (*non* figs. 2-3 —strobili terminal to axes).

1893 *Sphenophyllum trichomatosum* STUR - KIDSTON, On the fructification of Sphenophyllum trichomatosum, Stur, from the Yorkshire Coal Field, pp. 59-62, pl. I, figs 1-4.

1907 *Sphenophyllum trichomatosum* STUR - ZALESSKY, Flore fossile du Donetz. I. Collection Domherr, pp.373-378, Tab.XIII, figs. 5, 5a, Tab.XVII, figs. 1, 1a.

1938 *Sphenophyllum trichomatosum* STUR - BELL, Sydney Coalfield, Nova Scotia, p. 90, pl.XCIII, figs. 7-8.

1952 *Sphenophyllum trichomatosum* STUR - NOVIK, Coal Measure Flora of the European Part of the USSR, p.112, Tab. XIII, figs 5-6.

1959 *Sphenophyllum trichomatosum* STUR - EGEMEN, İhsaniye Beds at Kozlu, Zonguldak, p.7, pl.I, fig.4.

1961 *Sphenophyllum trichomatosum* STUR - TENČOV, Karbonische Flora um Grube «Berov Dol» bei Svoge, p.152, Tab.II, figs 5-6a.

1962 *Sphenophyllum trichomatosum* STUR - BELL, Pictou Group, New Brunswick, pp.47-48, pl.XLII, fig.5.

1964 *Sphenophyllum* ?n. spp. DRÄGERT, Pflanzensoziologische Untersuchungen, p.64, Taf.10, figs 1-3.

Material.—Several leaf verticils spread out and in longitudinal compression.

Description of the material in hand.—Ribbed *Sphenophyllum* axes with verticils of six leaves which are deeply dissected with the limb following the outline of the nervation. Leaves mainly divided once at about one third of their length, with one of the two branches dichotomizing again in some cases (the second dichotomy taking place fairly quickly). The linear leaf segments taper into a point at the end of the leaves. Dimensions of the leaves are rather small, 4-5 mm in length and *ca.* 1.5 mm in width for the once bifurcate ones, and *ca.* 2 mm width for trifurcate leaves.

Remarks.—The linear leaf segments with the outline of the limb following the venation, show a close resemblance to another deeply dissected kind of leaf belonging to *Sphenophyllum tenerrimum* VON ETTINGSHAUSEN. The latter however, has been described as possessing obtuse leaf segments, whereas *Sphenophyllum trichomatosum* is characterized by pointed segments. The axes of *S. trichomatosum* have been described as punctate, with hairs being found attached in some specimens. No hair bases have been found on the material in hand. It has also been mentioned that *S. trichomatosum* possesses up to 8 leaves in a verticil, whilst 6 leaves per verticil are found to be present in the specimens described here. These differences are not considered to be sufficiently important to separate the material in hand from the species discussed, since so much depends on preservation and on the position of the leaf verticils on the plant.

Sphenophyllum trichomatosum does not seem to be a common species, but it has been recorded from a wide geographical area, including Russia (Donbass), Turkey, Bulgaria, Silesia, Germany, Belgium, the Netherlands, Great Britain and Canada. It apparently ranges throughout the Westphalian. *Sphenophyllum trichomatosum* has also been mentioned from the United States, and this includes a reference to Stephanian strata (Monongahela) (ABBOTT 1958), but the drawing published to illustrate this species from the U. S. A. is unconvincing and ABBOTT's description is also subject to reservation. It may be that ABBOTT's drawing, subsequently reproduced in the Traité de Paléobotanique (vol. III, p.90), prevented DRÄGERT (1964) from admitting the identity of his material with *Sphenophyllum trichomatosum* STUR.

Occurrence.—Locality 15 (DPO 1193, 1199).

Sphenophyllum emarginatum BRONGNIART
Pl.3, figs 1, 1b; Pl.17, figs 2, 2a, 5.

1822 *Sphenophyllites emarginatus* BRONGNIART, Classification et distribution des végétaux fossiles, p.34, pl.II, fig.8.

1828 *Sphenophyllum emarginatum* BRONGNIART, Prodrome, p.68.

1966 *Sphenophyllum emarginatum* BRONGNIART - STORCH, *Sphenophyllum* im Zwickau-Lugau-Oelsnitzer Steinkohlenrevier, p.200, Abb.1 (reproduction of BRONGNIART's original figure of holotype), pp. 277-287, Abb. 16, 17, 24, 25, Taf. V, fig. 3, Taf. XIV, figs 2-4, Taf. XV, figs 1-2, Taf. XVI, figs 1-2, Tafn XVII-XXII, Taf. XXIII, figs 1-3.

1966 *Sphenophyllum emarginatum* BRONGNIART - WAGNER, Palaeobotanical Dating of Upper Carboniferous Folding Phases in NW. Spain, pp. 28, 29, 31, 32, 33, 46, 133, pl. 18, fig. 40.

1966 *Sphenophyllum emarginatum* BRONGNIART - STOCKMANS & WILLIÈRE, Documents paléobotaniques pour l'étude du Houiller dans le Nord-Ouest de l'Espagne, pl. XI, fig. 5.

1966 *Sphenophyllum truncatum* SCHIMPER - STOCKMANS & WILLIÈRE, Documents, pl. VI, figs 1, 1a, pl. IX, fig. 7 (*non* pl. XI, fig. 6 = *Sphenophyllum nageli* GRAND'EURY?).

Material.—Several leaf whorls, some of which are still attached to axes. The preservation is as impressions in silty mudstone.

Description of the material in hand.—Rather slender ribbed axes with verticils of six relatively broad and small leaves (dimensions: *ca.* 6 mm long and 4 mm wide) which show straight to slightly convex lateral margins and an almost truncate to slightly convex distal border. The latter shows a shallow cleft in the middle, and moderately large rounded teeth which are apparently eight in number on the specimens in hand.

Remarks.—This species has been recently described in detail by STORCH (1966), who also discussed the literature. He mentioned the leaves as being 6 or 9 in a whorl, rather small (2-17 mm long, 2-10 mm wide on the distal border), with a straight or convex distal border showing sometimes a central cleft (e.g. BRONGNIART's original type), but being more generally entire. The distal border would show 4-18 blunt, semi-circular teeth. A considerable range in the length/breadth ratio was admitted, with rather slender forms showing up to a 5 : 1 ratio and broader forms down to a 1.1 : 1 ratio. Since the original type was reported as lost, a neotype was designated by STORCH after material from the Westphalian D strata of Zwickau, Saxony.

The specimens in hand fit the description given by STORCH and fall within the morphological variation indicated. They also show a good resemblance with regard to the essential characteristics, to the type specimen as figured by BRONGNIART (1822), the type being also characterized by relatively wide leaves, six to a whorl, and showing a shallow cleft in the distal margin.

Sphenophyllum emarginatum is a very common species which has been reported from Westphalian B, C and D, and lower Stephanian strata in Europe and North America. HALLE (1927) figured it from the Lower Permian of China.

There are numerous records of this species from Northwest Spain (e.g. ZEILLER, 1882, reported it from four localities in the central Asturian coalfield), and two papers (WAGNER 1966, STOCKMANS & WILLIÈRE 1966) provide illustrations. STOCKMANS & WILLIÈRE also figured specimens under the name of *Sphenophyllum truncatum* SCHIMPER, which is usually regarded as a junior synonym.

Occurrence.—Locality 14 (DPO 1106, 1115, 1132, 1138, 1151, 1155, 1159, 1162, 1164, 1166).

Annularia sphenophylloides (ZENKER) VON GUTBIER
Pl. 17, fig. 4

R e m a r k s.—Several leaf whorls are present of this very characteristic species which ranges from Westphalian C to Autunian. It is easily recognized by its small and relatively wide, spatulate leaves which, if well enough preserved, show the presence of a mucron.

O c c u r r e n c e.—Locality 12 (DPO 1208, 1209).

Calamites sp.

Poorly preserved pith casts of *Calamites* were obtained from locality 10 (DPO 1206).

Aphlebia sp.

One specimen from Locality 14 (DPO 1163).

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EXPLANATION OF PLATES

All the figured specimens are in the Department of Palaeontology, Faculty of Science, University of Oviedo, and the numbers prefixed DPO refer to the Catalogue in this Department. The specimens are figured at natural size and/or three times enlarged. An enlargement × 6 has been used on one occasion. Locality numbers quoted refer to those described on page 464 and stated in text-fig. 1. The localities were made available by Mr. J. PELLO. Photographs by Mr. B. PIGOTT.

PLATE 1

Fig. 1.—*Alethopteris grandinioides* KESSLER var. *grandinioides* and *Linopteris obliqua* (BUNBURY) ZEILLER, × 1. DPO 1104. Loc. 14 at Malpica, Olloniego Formation (at 15 metres below the top of this formation).

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Alethopteris grandinioides* KESSLER var. *grandinioides* and *Neuropteris scheuchzeri* HOFFMANN, × 1. DPO 1101. Loc. 14 at Malpica, Olloniego Formation.

Fig. 3—*Neuropteris scheuchzeri* HOFFMANN, × 1. DPO 1102. Loc. 14 at Malpica, Olloniego Formation.

Fig. 4.—*Alethopteris grandinioides* KESSLER var. *grandinioides*, × 1. DPO 1131. Loc. 14 at Malpica, Olloniego Formation.

Fig. 5.—*Callipteridium (Praecallipteridium) armasi* (ZEILLER) WAGNER, × 1. DPO 1207. Loc 10, tip of abandoned coal mine at 2 km north-east of Olloniego, Esperanza Formation.

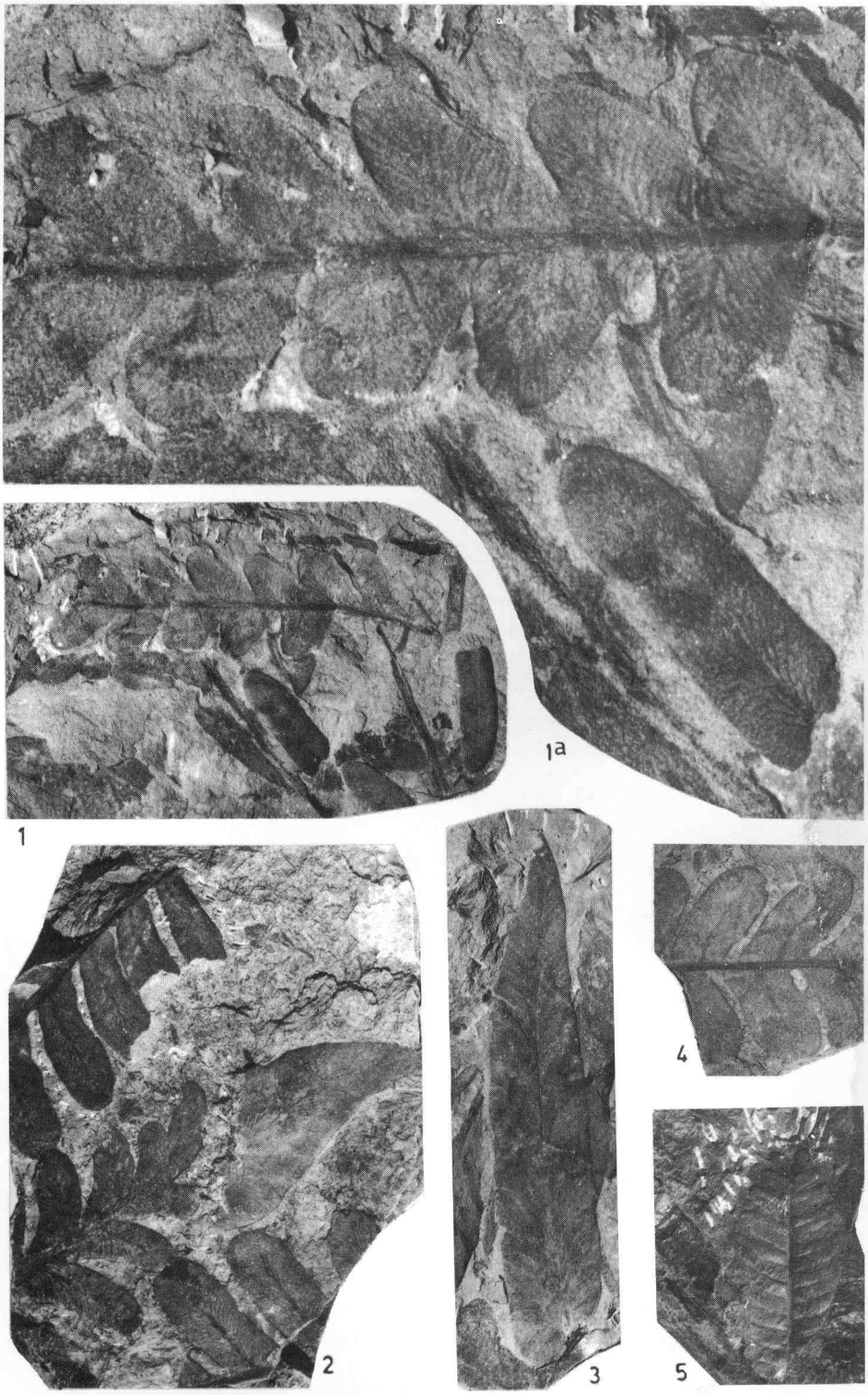

1a
1
2
3
4
5

PLATE 2

Fig. 1.—*Callipteridium (Praecallipteridium) armasi* (ZEILLER) WAGNER, × 3. DPO 1207. Loc. 10, tip of abandoned coal mine at 2 km north-east of Olloniego, Esperanza Formation.

Fig. 2.—*Linopteris obliqua* (BUNBURY) ZEILLER, × 3. DPO 1203. Loc. 10, abandoned mine 2 km north-east of Olloniego, Esperanza Formation.

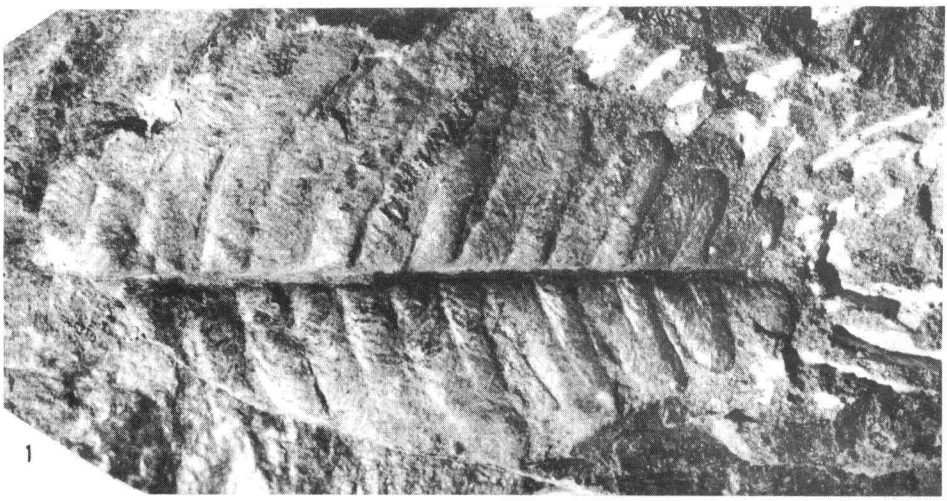
Fig. 3.—*Linopteris obliqua* (BUNBURY) ZEILLER, × 3. DPO 1152. Loc. 14 at Malpica, Olloniego Formation.

Fig. 4.—*Linopteris obliqua* (BUNBURY) ZEILLER, × 3. DPO 1132 (figured natural size on Pl. 10, fig. 4). Loc. 14 at Malpica, Olloniego Formation.

Fig. 5.—*Mixoneura* sp. (cf. *peyerimhoffi* P. BERTRAND), × 3. DPO 1213 (figured natural size on Pl. 5, Fig. 5). Loc. 16, tip of Mina Postrera, 2.3 km south of Olloniego, Ablanedo Formation.

Fig. 6.—*Neuropteris* cf. *tenuifolia* (VON SCHLOTHEIM) BRONGNIART, × 1. DPO 1211. Loc. 12 at Malpica, Esperanza Formation.

Fig. 6a.—The same specimen, × 3.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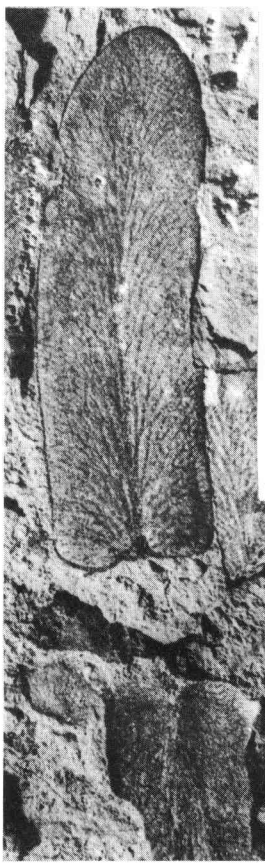
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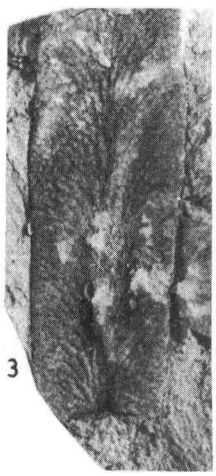
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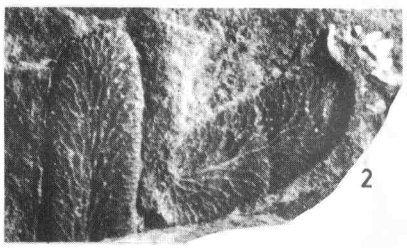
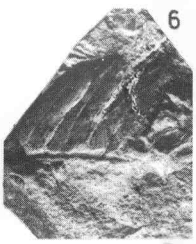

2


5


6


6a

PLATE 3

Fig. 1.—*Alethopteris grandinioides* KESSLER var. *grandinioides*, *Linopteris obliqua* (BUNBURY) ZEILLER and *Sphenophyllum emarginatum* BRONGNIART, × 1. DPO 1106. Loc. 14 at Malpica, Olloniego Formation.

Figs. 1a-b.—The same specimen, × 3.

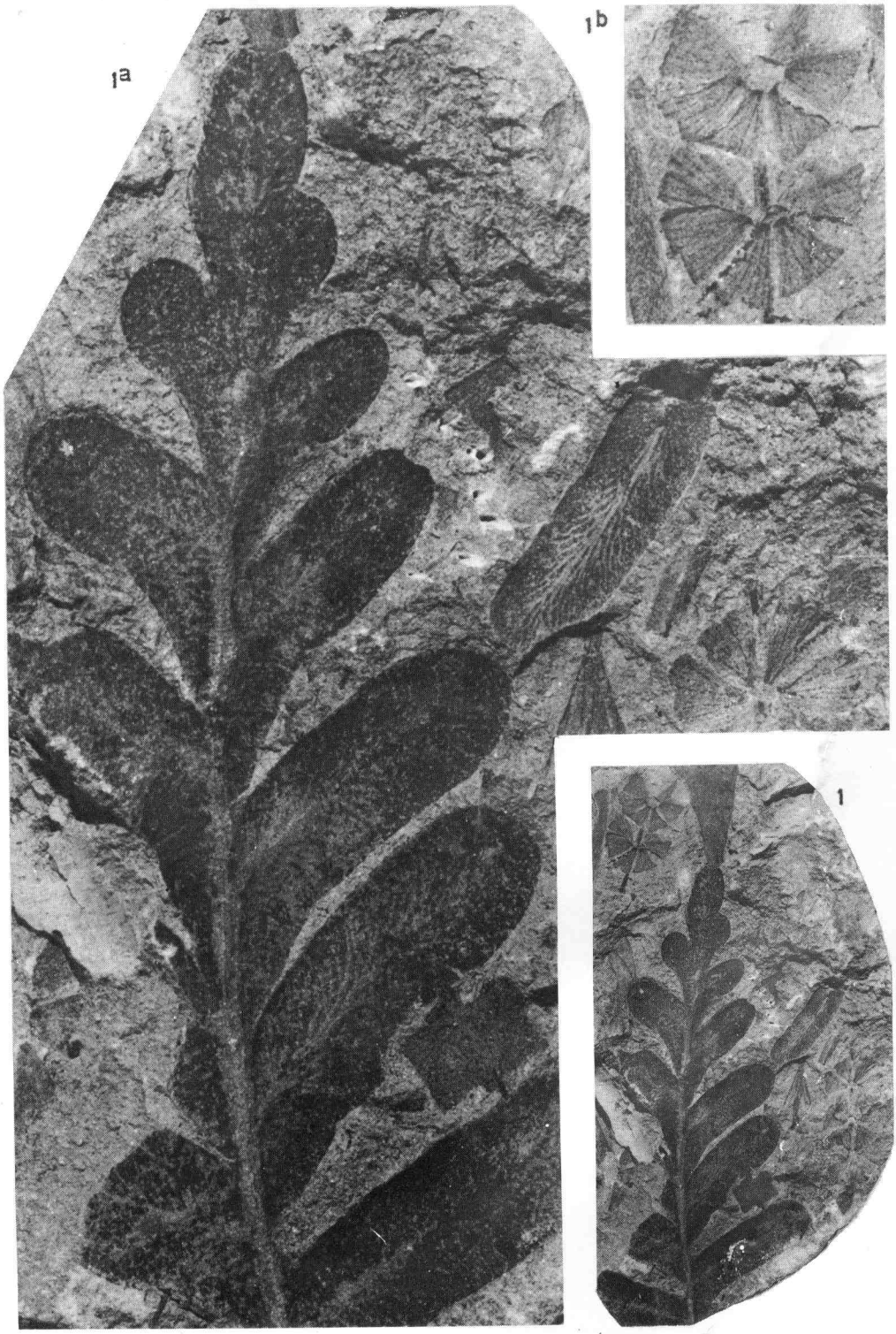

1a
1b
1

PLATE 4

Fig. 1.—*Mariopteris (Fortopteris) latifolia (non* BRONGNIART?) ZEILLER, × 1. Basal part of a frond showing two successive dichotomies. DPO 1172. Loc. 15 at Pumardongo, Olloniego Formation. The same specimen also shows a fragment of a pinna of *Lobatopteris serpentigera* WAGNER (compare Pl. 11, figs. 1, 1a).

Figs 1a-b.—Parts of the same specimen, × 3.

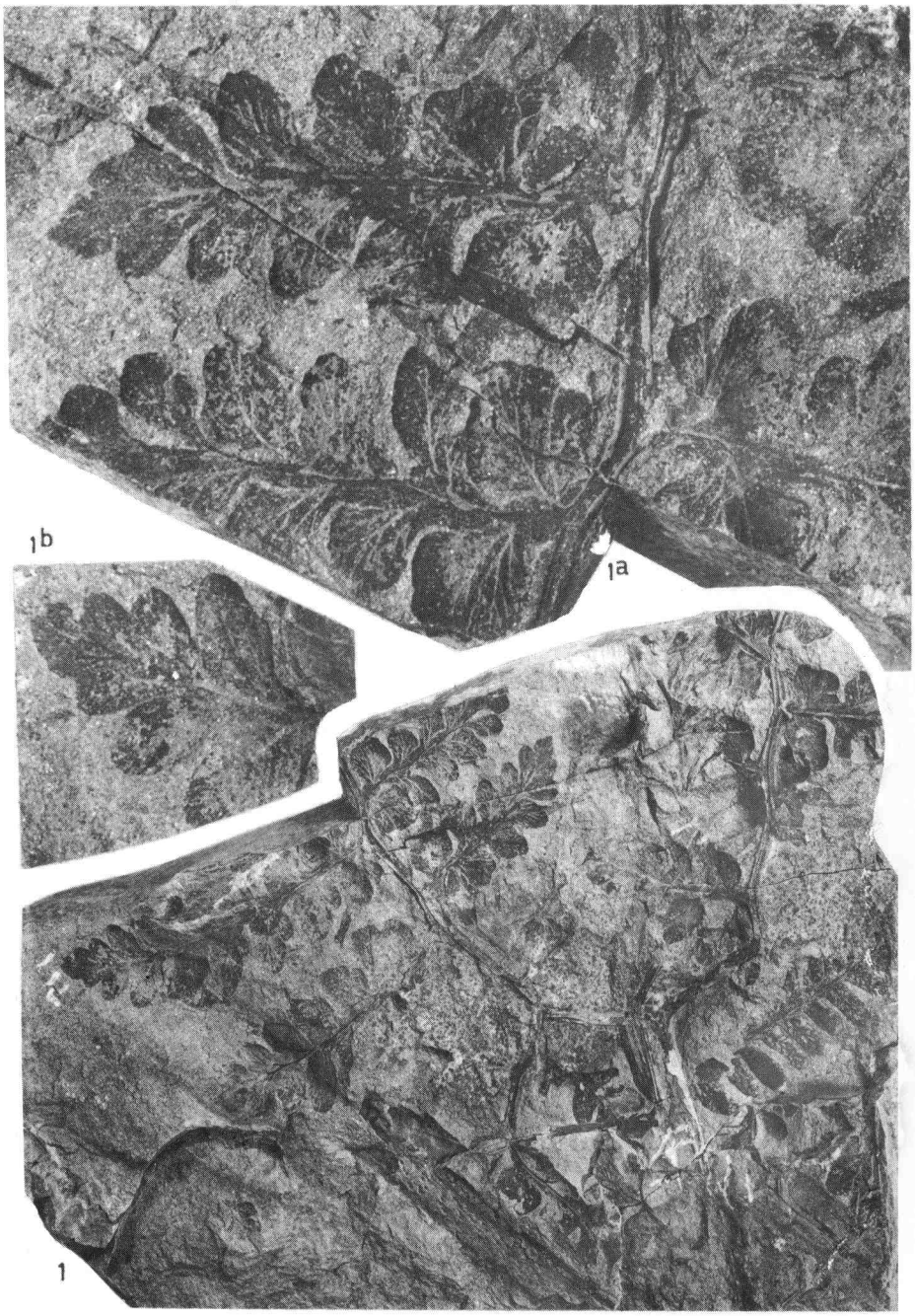

1b
1a
1

PLATE 5

Fig. 1.—*Dicksonites potieri* (ZEILLER) P. BERTRAND, × 1. DPO 1196. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Dicksonites potieri* (ZEILLER) P. BERTRAND, × 1. DPO 1204. Loc. 10, abandoned coal mine 2 km north-east of Olloniego, Esperanza Formation.

Fig. 2a.—The same specimen, × 3.

Fig. 3.—*Mariopteris (Fortopteris) latifolia (non* BRONGNIART?) ZEILLER, × 1. DPO 1190. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 3a.—The same specimen, × 3.

Fig. 4.—*Mariopteris (Fortopteris) latifolia (non* BRONGNIART?) ZEILLER, × 1. DPO 1187. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 4a.—The same specimen, × 3.

Fig. 5.—*Mixoneura* sp. (cf. *peyerimhoffi* P. BERTRAND), × 1. DPO 1213 (figured × 3 on Pl. 2, fig. 5). Loc. 16, tip of Mina Postrera, 2.3 km south of Olloniego, Ablanedo Formation.

Fig. 6.—*Linopteris obliqua* (BUNBURY) ZEILLER, × 3. DPO 1214. Loc. 16, tip of Mina Postrera, Ablanedo Formation.

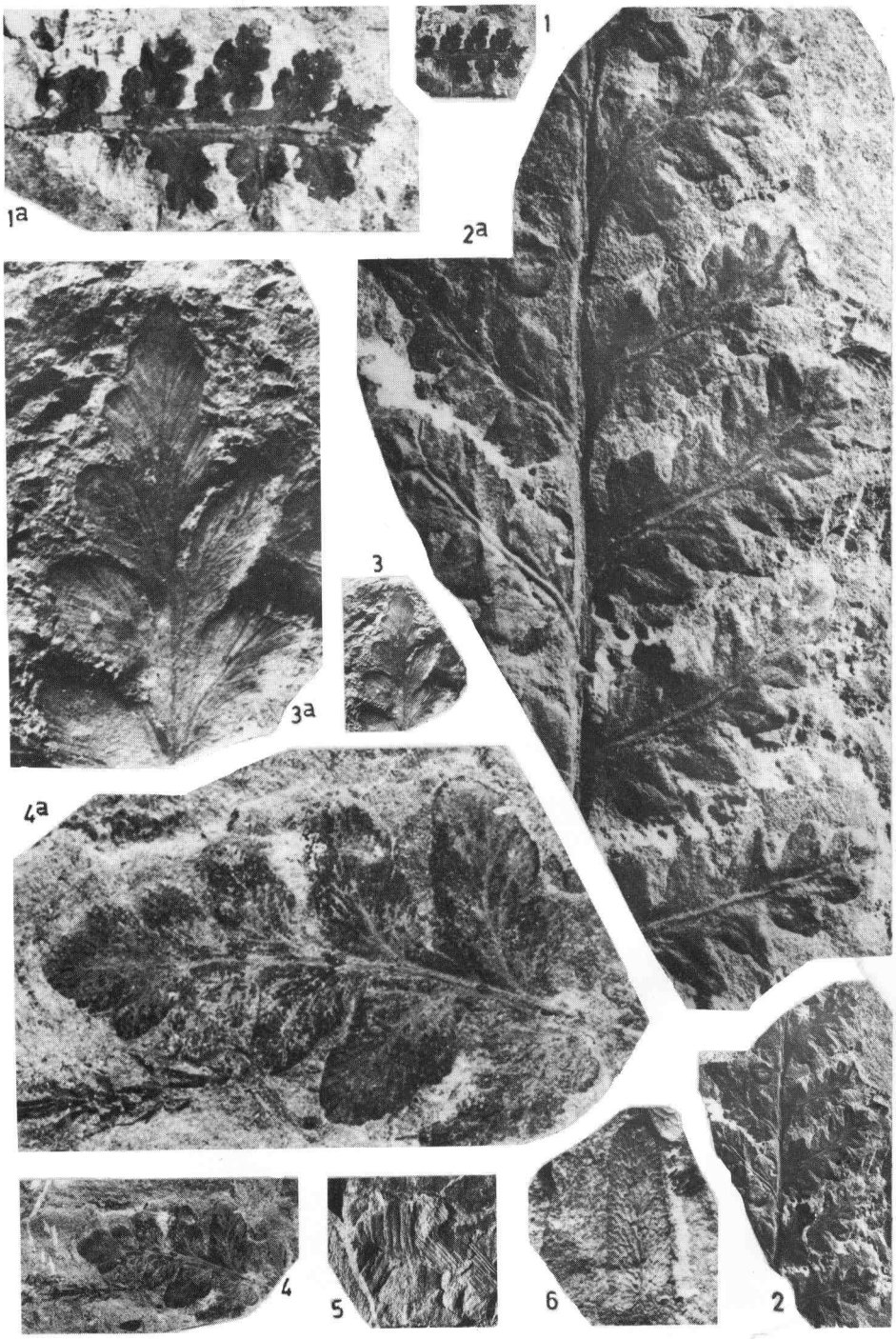

1a
1
2a
3
3a
4a
4
5
6
2

PLATE 6

Fig. 1.—*Mariopteris (Fortopteris) latifolia (non* BRONGNIART?) ZEILLER, × 1. DPO 1173. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Sphenopteris nummularia* VON GUTBIER, × 1. DPO 1205. Loc. 10, tip of abandoned coal mine at 2 km north-east of Olloniego, Esperanza Formation.

Fig. 2a.—The same specimen, × 3.

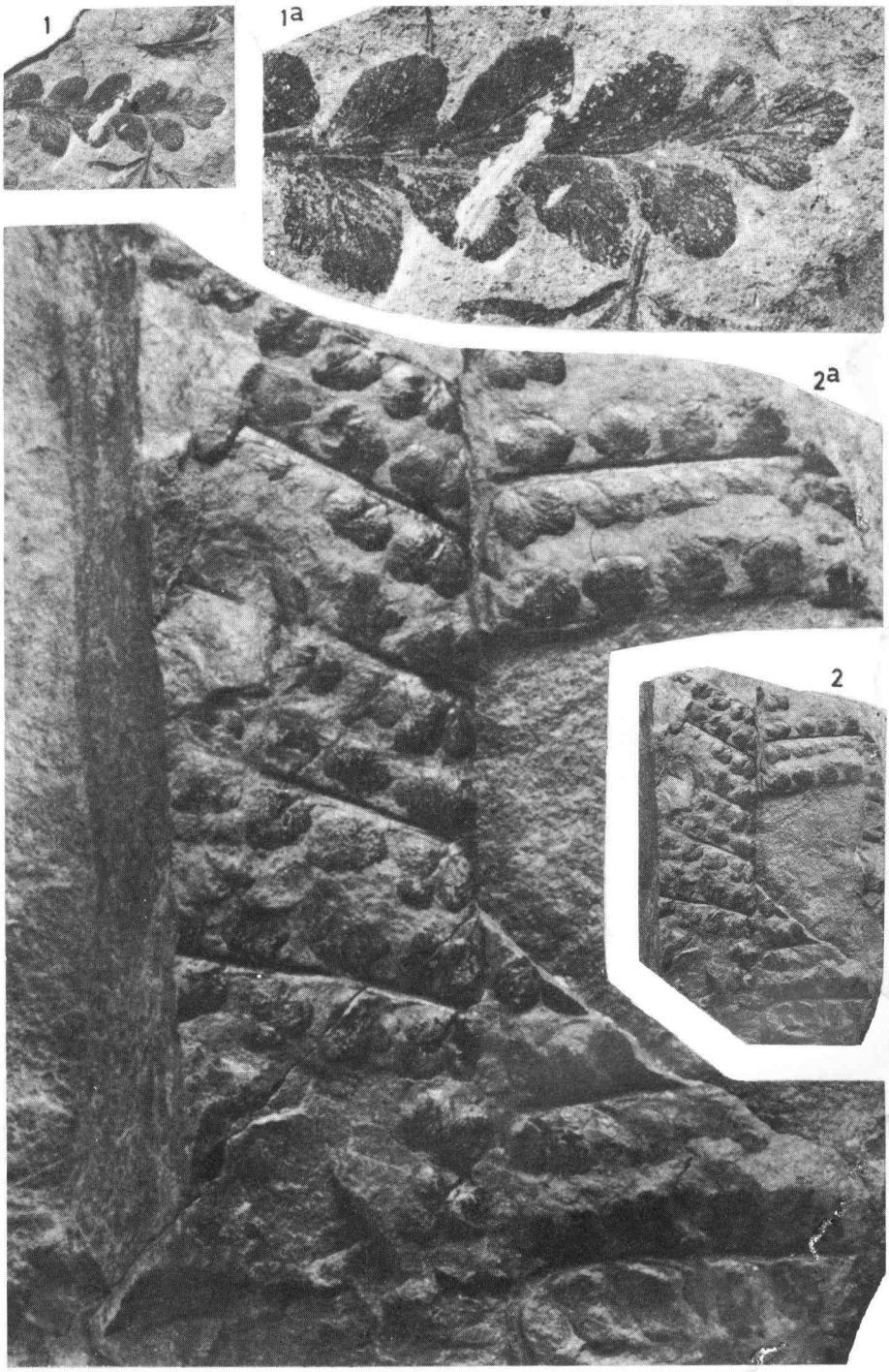

1
1a
2a
2

PLATE 7

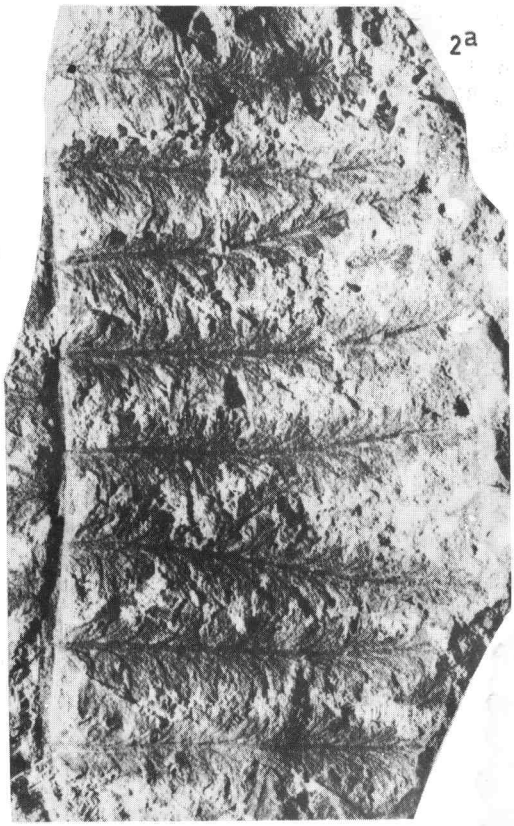
Fig. 1.—*Alloiopteris cristata* (VON GUTBIER) NĚMEJC and *Neuropteris scheuchzeri* HOFFMANN, × 1. DPO 1114. Loc. 14 at Malpica, Olloniego Formation.

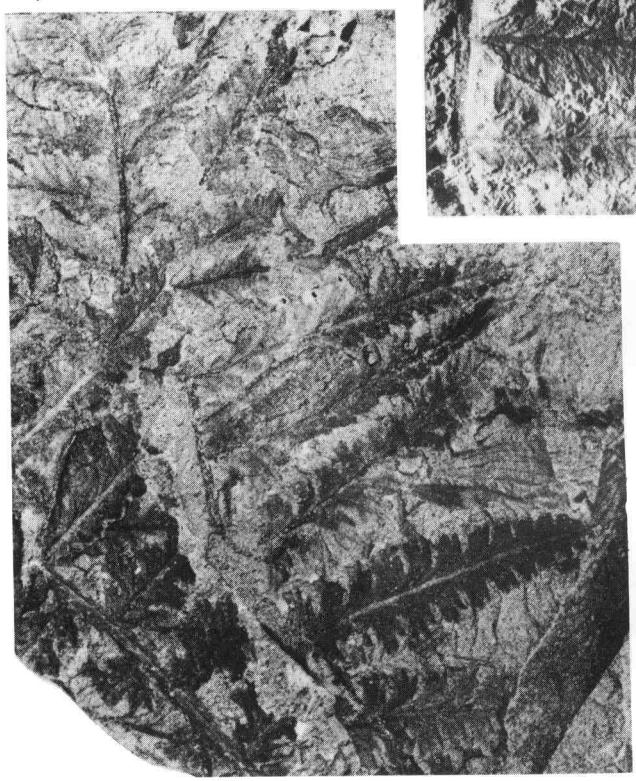
Fig. 1a.—Part of the same specimen *(A. cristata)*, × 3.

Fig. 2.—*Alloiopteris cristata* (VON GUTBIER) NĚMEJC, × 1. DPO 1133. Loc. 14 at Malpica, Olloniego Formation.

Fig. 2a.—The same specimen, × 3.


1


2a


1a


2

PLATE 8

Fig. 1.—*Sphenopteris* cf. *amoena* (STUR) KIDSTON, × 1. DPO 1165. Loc. 14 at Malpica, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Sphenopteris pelloi* sp. nov., × 3. Topotype showing the nervation. DPO 1126. Loc. 14 at Malpica, Olloniego Formation.

Fig. 3.—*Alloiopteris cristata* (VON GUTBIER) NĚMEJC, × 1. DPO 1140. Loc. 14 at Malpica, Olloniego Formation.

Fig. 3a.—The same specimen, × 3.

Fig. 4.—*Alloiopteris erosa* (VON GUTBIER) D. WHITE, × 1. DPO 1178. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 4a.—The same specimen, × 3.

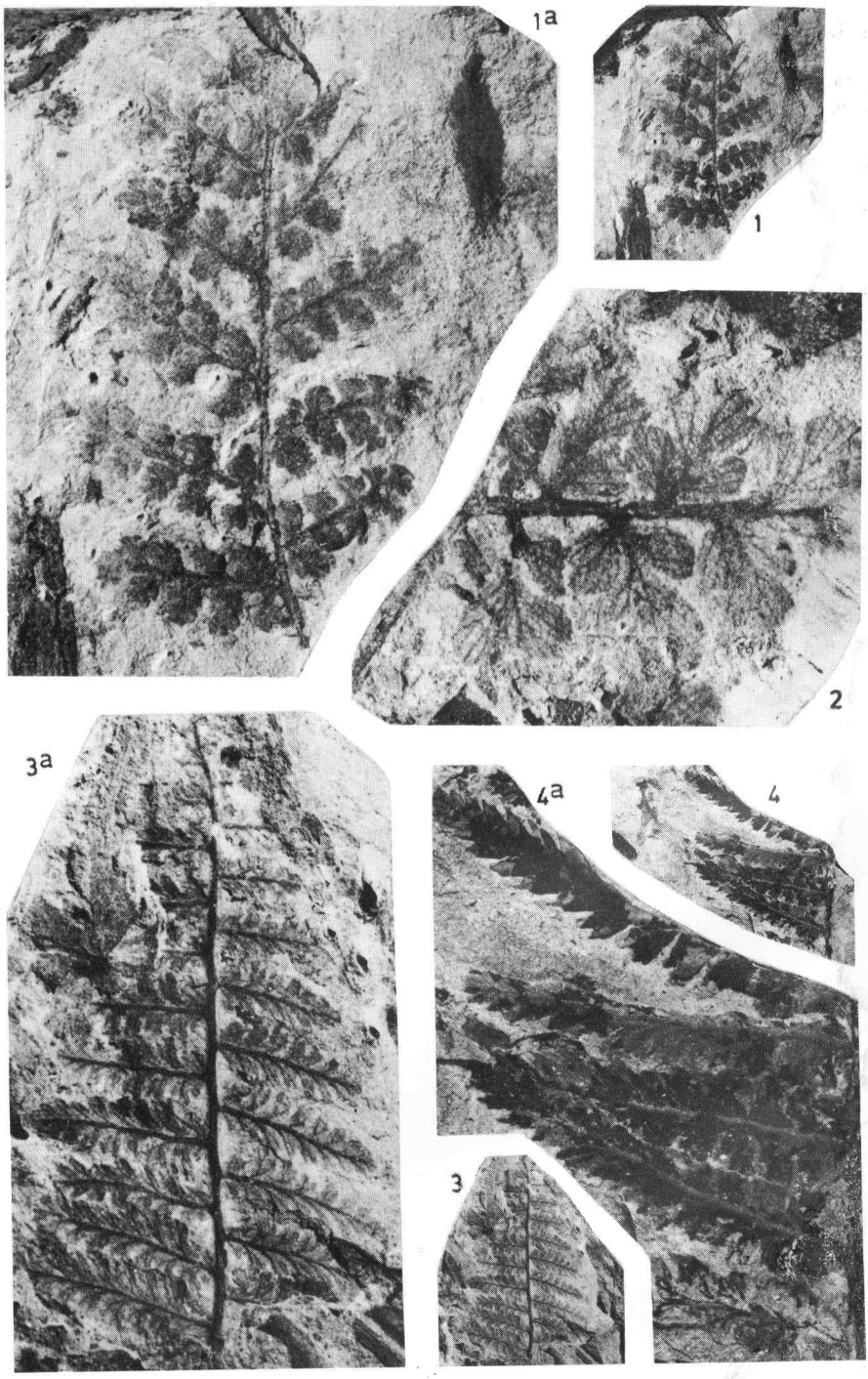

1a
1
2
3a
4a
4
3

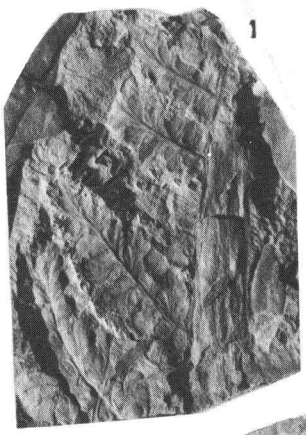
PLATE 9

Fig. 1.—*Sphenopteris pelloi* sp. nov., × 1. Holotype. DPO 1125. Loc. 14 at Malpica, Olloniego Formation.

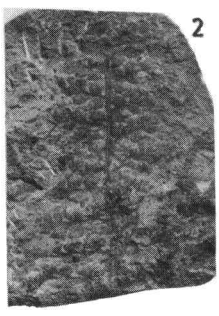
Fig. 1a.—The same specimen, × 3.

Fig. 3.—*Sphenopteris nummularia* VON GUTBIER, × 1. DPO 1160. Loc. 14 at Malpica, Olloniego Formation.

Fig. 2a.—The same specimen, × 3.


1

1a


2


2a

PLATE 10

Fig. 1.—*Sphenopteris opulenta* DANZÉ and *Pecopteris punctata* CORSIN, × 1. DPO 1185. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Sphenopteris chaerophylloides* (BRONGNIART) PRESL, × 1. DPO 1201. Loc. 10, abandoned mine at 2 km north-east of Olloniego, Esperanza Formation.

Fig. 2a.—The same specimen, × 3.

Fig. 3.—*Sphenopteris* cf. *sewardi* KIDSTON, × 1. DPO 1205. Loc. 10, abandoned mine at 2 km north-east of Olloniego, Esperanza Formation.

Fig. 3a.—The same specimen, × 3.

Fig. 4.—*Linopteris obliqua* (BUNBURY) ZEILLER, × 1. DPO 1132 (same as figured × 3 on Pl. 2, fig. 4 and Pl. 10, fig. 6). Loc. 14 at Malpica, Olloniego Formation.

Fig. 5.—*Palmatopteris membranacea* (VON GUTBIER) STERZEL, × 3. DPO 1170. Loc. 14 at Malpica, Olloniego Formation.

Fig. 6.—Part of the same specimen as figured on Pl. 10, fig. 4, × 3.

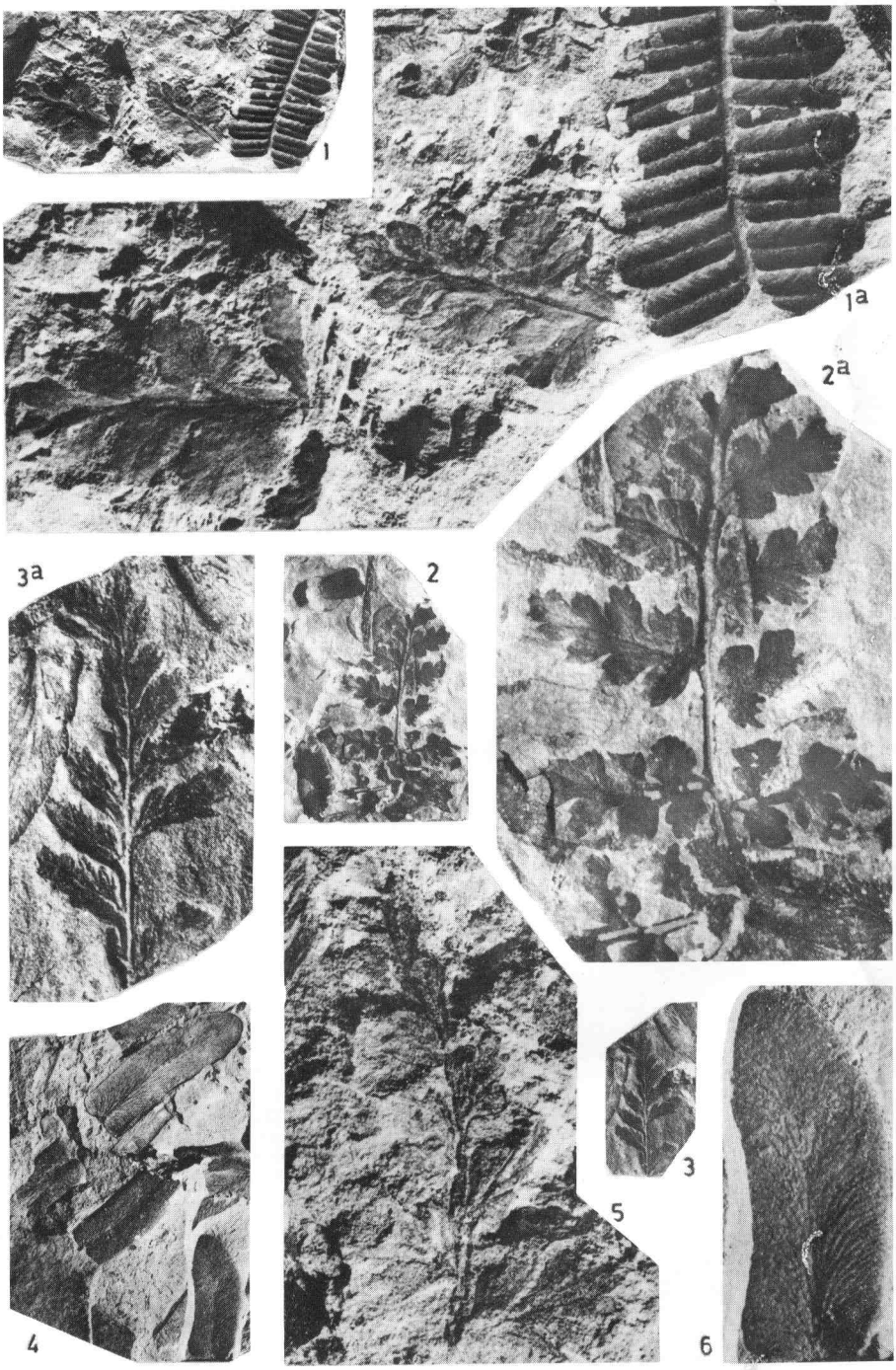

1
1a
2a
3a
2
4
5
3
6

PLATE 11

Fig. 1.—*Lobatopteris serpentigera* WAGNER, × 1. DPO 1172. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 1a.—The same specimen × 3.

Fig. 2.—*Lobatopteris serpentigera* WAGNER, × 1. DPO 1188. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 2a.—The same specimen, × 3.

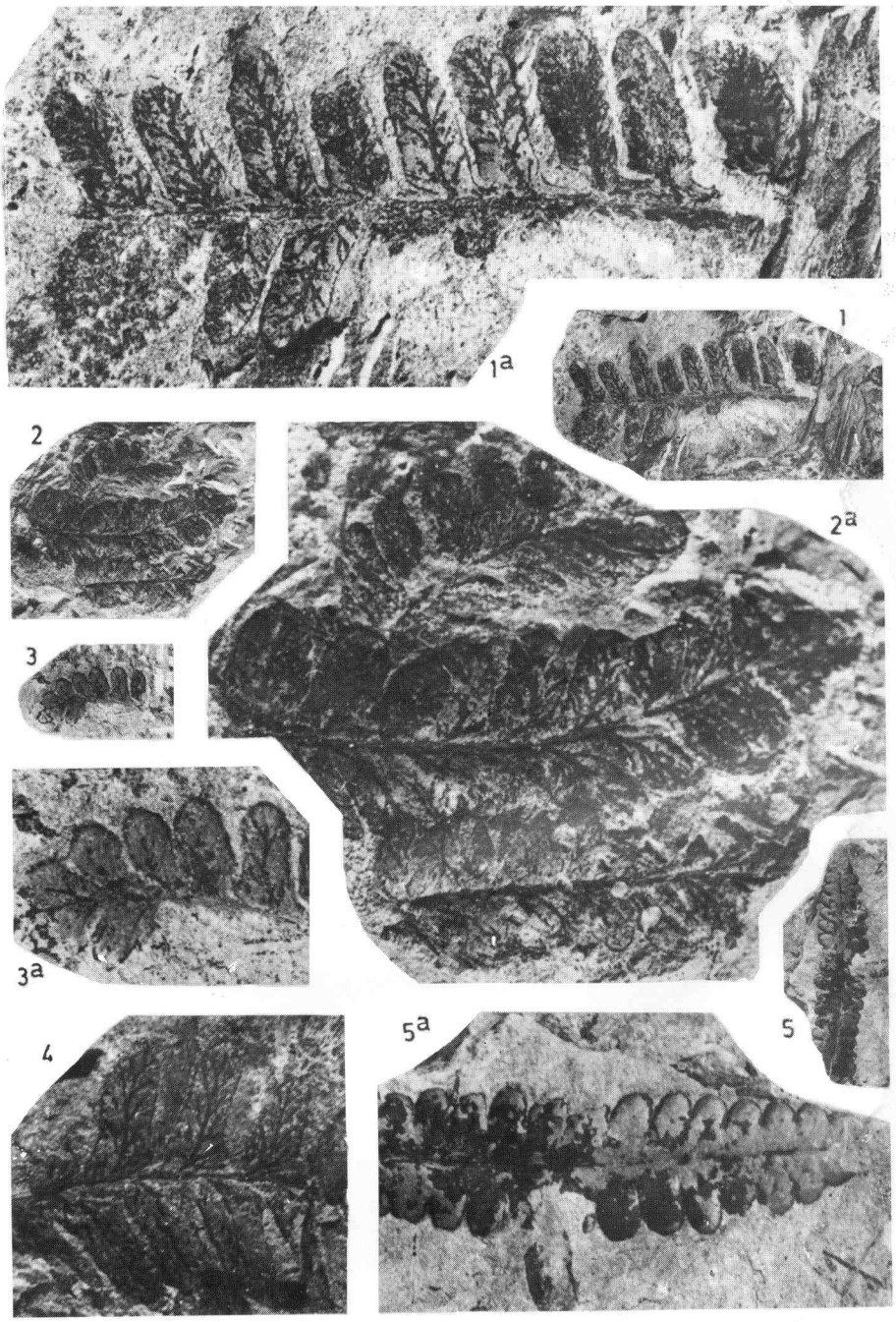
Fig. 3.—*Lobatopteris serpentigera* WAGNER, × 1. DPO 1196. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 3a.—The same specimen, × 3.

Fig. 4.—*Lobatopteris serpentigera* WAGNER, × 3. DPO 1188. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 5.—*Pecopteris unita* BRONGNIART, × 1. DPO 1186. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 5a.—The same specimen, × 3.


1a
1
2
2a
3
3a
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5a
5

PLATE 12

Fig. 1.—*Pecopteris* cf. *obliquenervis* CORSIN, × 1. DPO 1152. Loc. 14 at Malpica, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Pecopteris* cf. *obliquenervis* CORSIN, × 1, DPO 1139. Loc. 14 at Malpica, Olloniego Formation.

Fig. 2a.—The same specimen, × 3.

Fig. 3.—*Pecopteris (Asterotheca) miltoni* (ARTIS) BRONGNIART, × 3. DPO 1118 (same as figured at natural size on Pl. 13, fig. 1). Loc. 14 at Malpica, Olloniego Formation.

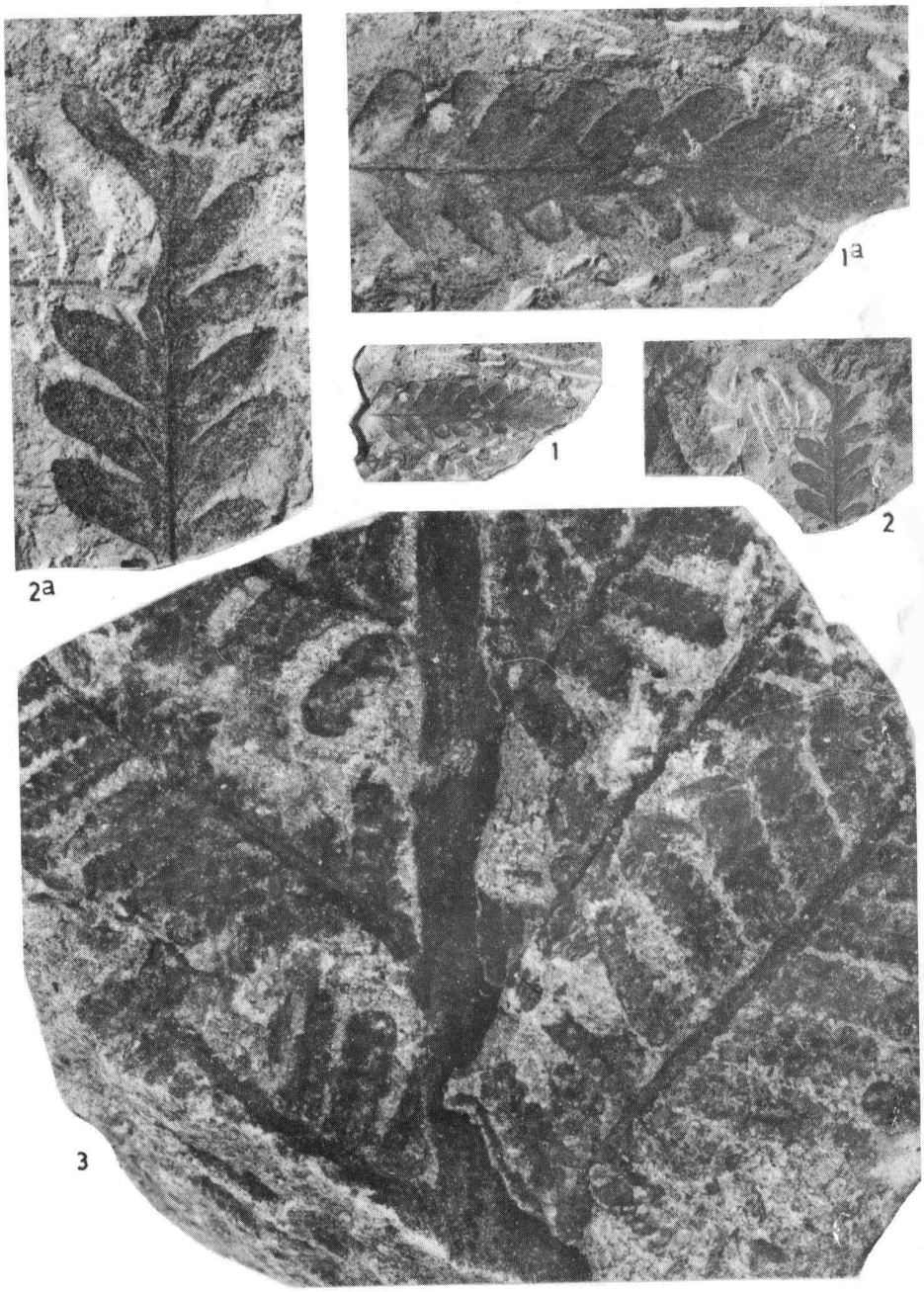

1a
1
2
2a
3

PLATE 13

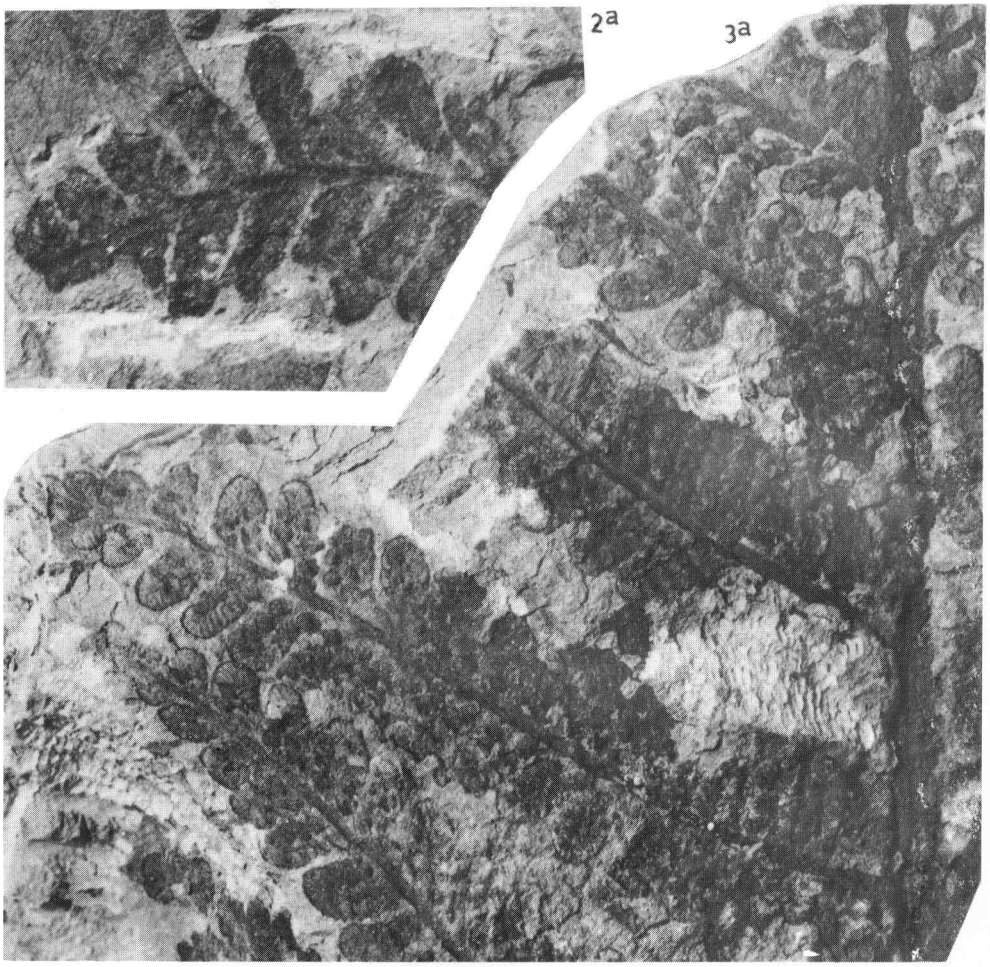
Fig. 1.—*Pecopteris (Asterotheca) miltoni* (ARTIS) BRONGNIART, × 1. DPO 1118 (same as figured × 3 on Pl. 12, fig. 3). Loc. 14 at Malpica, Olloniego Formation.

Fig. 2.—*Pecopteris (Asterotheca) miltoni* (ARTIS) BRONGNIART, × 1. DPO 1119. Loc. 14 at Malpica, Olloniego Formation.

Fig. 2a.—The same specimen, × 3.

Fig 3.—*Pecopteris (Asterotheca) miltoni* (ARTIS) BRONGNIART, × 1. DPO 1117. Loc. 14 at Malpica, Olloniego Formation.

Fig. 3a.—The same specimen, × 3.


2a
3a

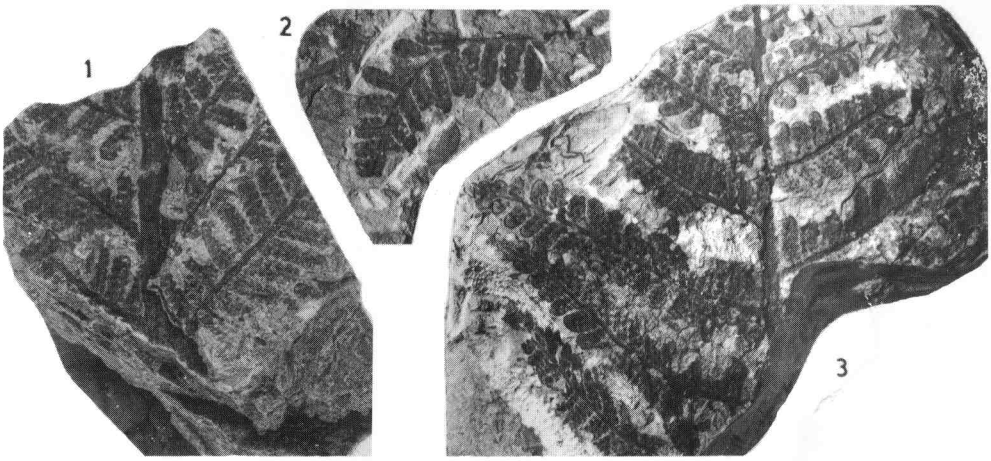

1
2
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PLATE 14

Fig. 1.—*Pecopteris punctata* CORSIN, × 1. DPO 1181. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Pecopteris punctata* CORSIN, × 1. DPO 1182 (same as figured × 3 on Pl. 15, fig. 4). Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 3.—*Pecopteris (Asterotheca) punctata* CORSIN, × 1. DPO 1183 (same as figured × 3 on Pl. 15, fig. 2). Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 4.—*Pecopteris (Asterotheca) punctata* CORSIN, × 3. DPO 1174. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 4a.—Part of the same specimen, × 6, in order to show the sporangia.

Fig. 5.—*Pecopteris (Asterotheca) punctata* CORSIN, × 1. DPO 1215. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 5a.—The same specimen, × 3.

Fig. 6.—*Pecopteris punctata* CORSIN, × 1. DPO 1180 (same as figured × 3 on Pl. 15, fig. 3). Loc. 15 at Pumardongo, Olloniego Formation.

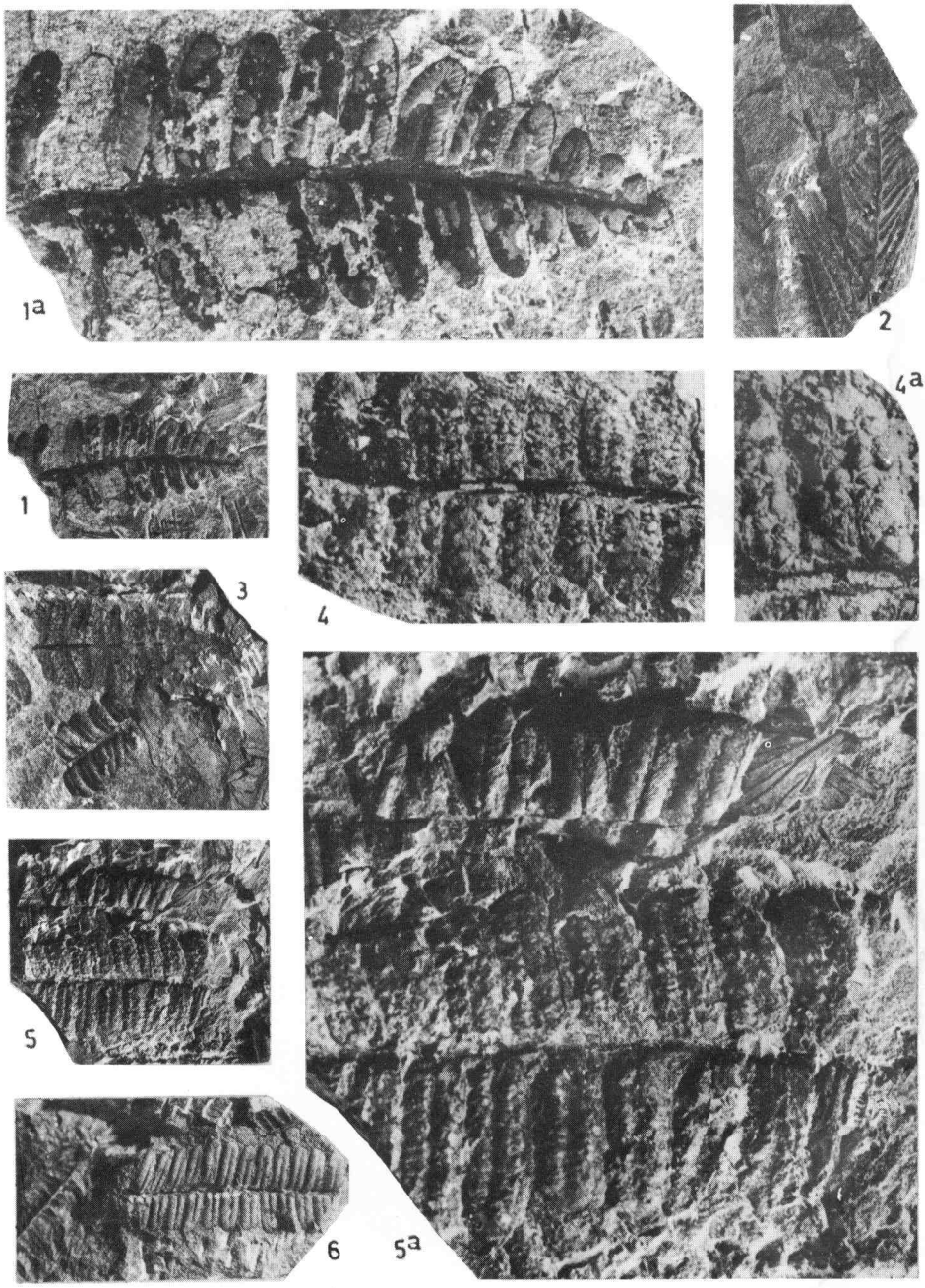
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PLATE 15

Fig. 1.—*Pecopteris punctata* CORSIN, × 1. DPO 1186. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Pecopteris (Asterotheca) punctata* CORSIN, × 3. DPO 1183 (same as figured natural size on Pl. 14, fig. 3). Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 3.—*Pecopteris punctata* CORSIN, × 3. DPO 1180 (same as figured natural size on Pl. 14, fig. 6). Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 4.—*Pecopteris punctata* CORSIN, × 3. DPO 1182 (same as figured natural size on Pl. 14, fig. 2). Loc. 15 at Pumardongo, Olloniego Formation.

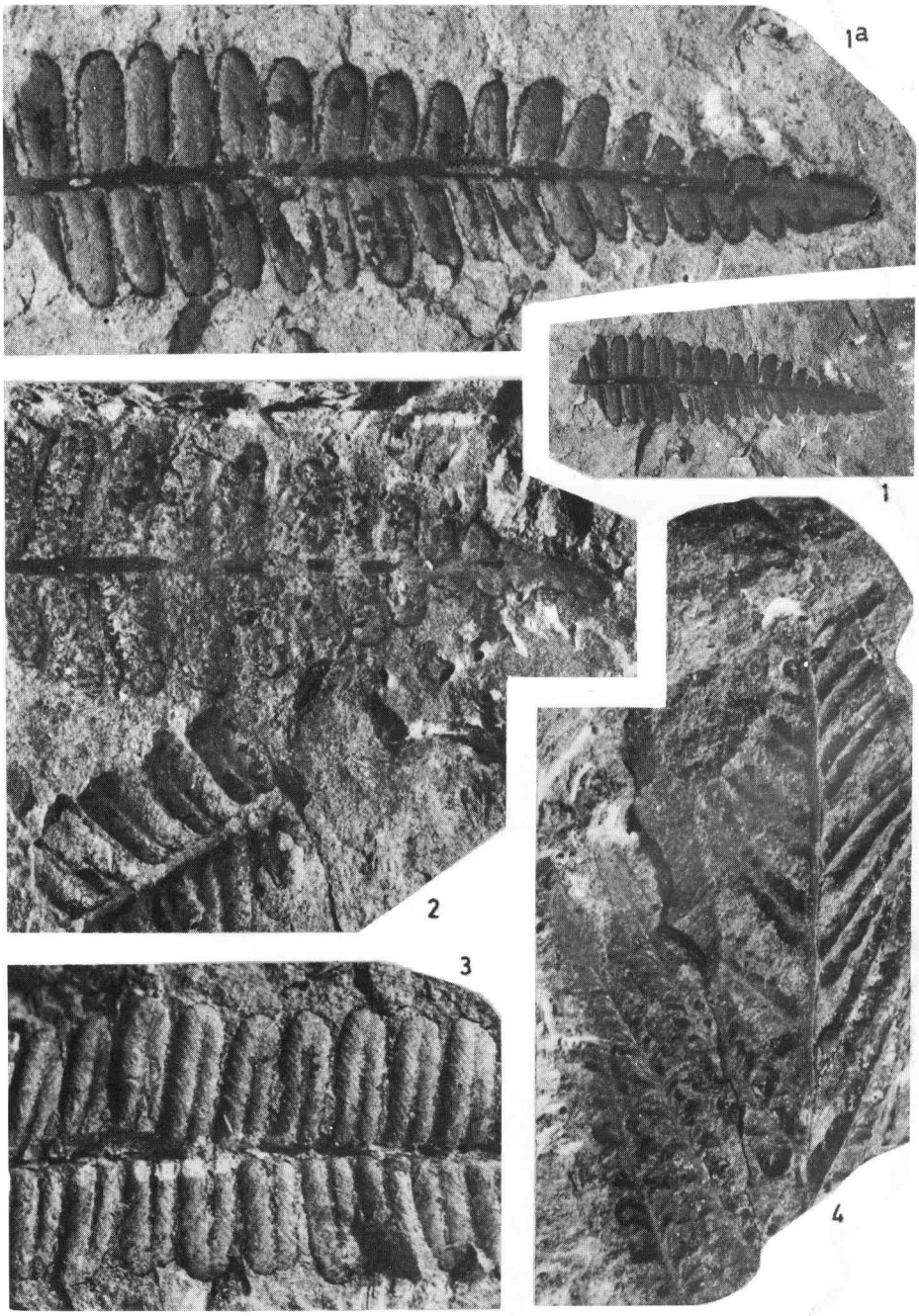
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PLATE 16

Fig. 1.—*Sphenophyllum orbiculare* REMY, × 1. DPO 1185. Loc. 15 at Pumardongo, Olloniego Formation.

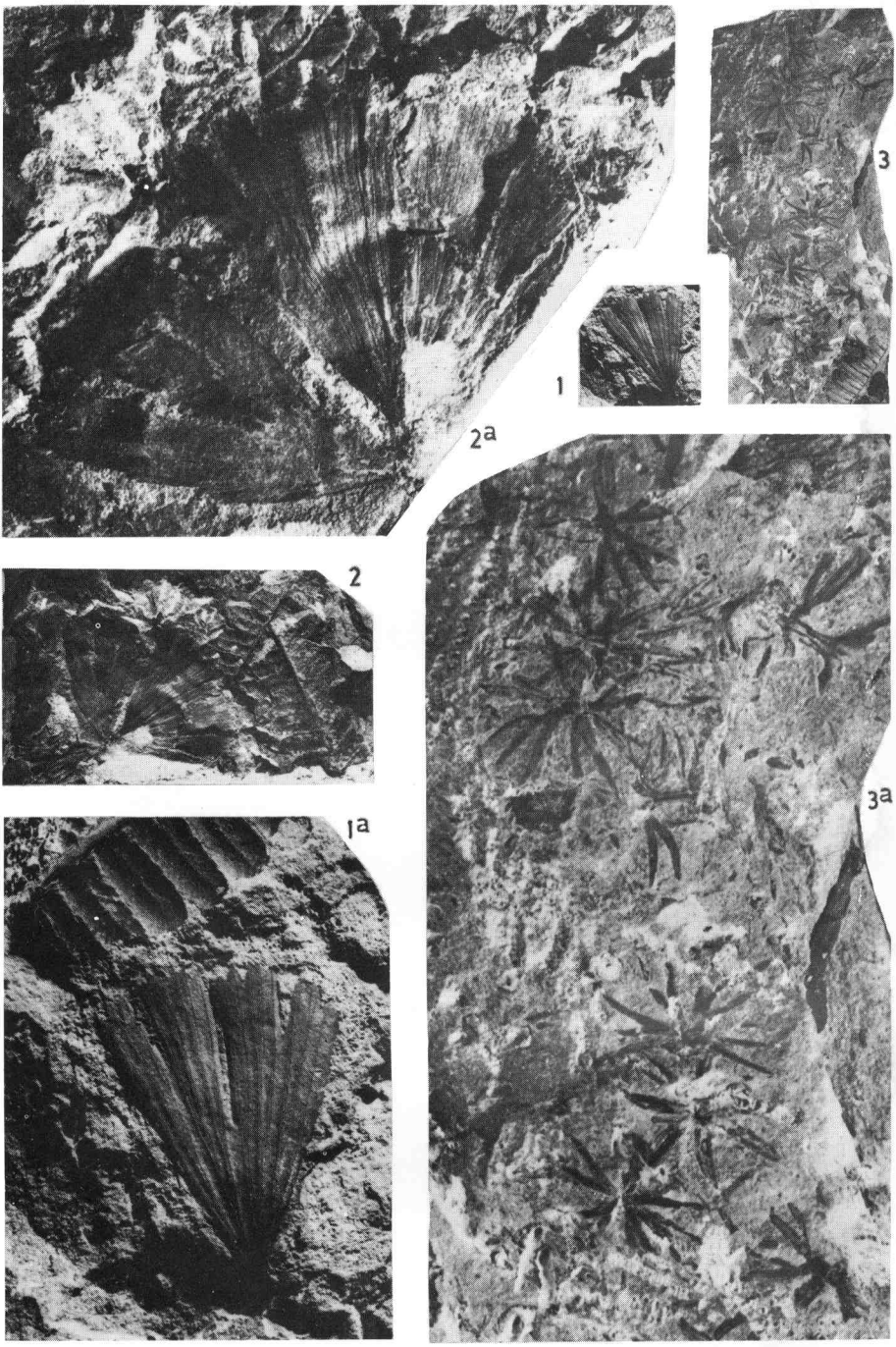
Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Sphenophyllum orbiculare* REMY, × 1. DPO 1194. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 2a.—The same specimen, × 3.

Fig. 3.—*Sphenophyllum trichomatosum* STUR, × 1. DPO 1193. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 3a.—The same specimen, × 3.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3a
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PLATE 17

Fig. 1.—*Pecopteris unita* BRONGNIART, × 1. DPO 1179. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 1a.—The same specimen, × 3.

Fig. 2.—*Sphenophyllum emarginatum* BRONGNIART and *Linopteris obliqua* (BUNBURY) ZEILLER, × 1. DPO 1151. Loc. 14 at Malpica, Olloniego Formation.

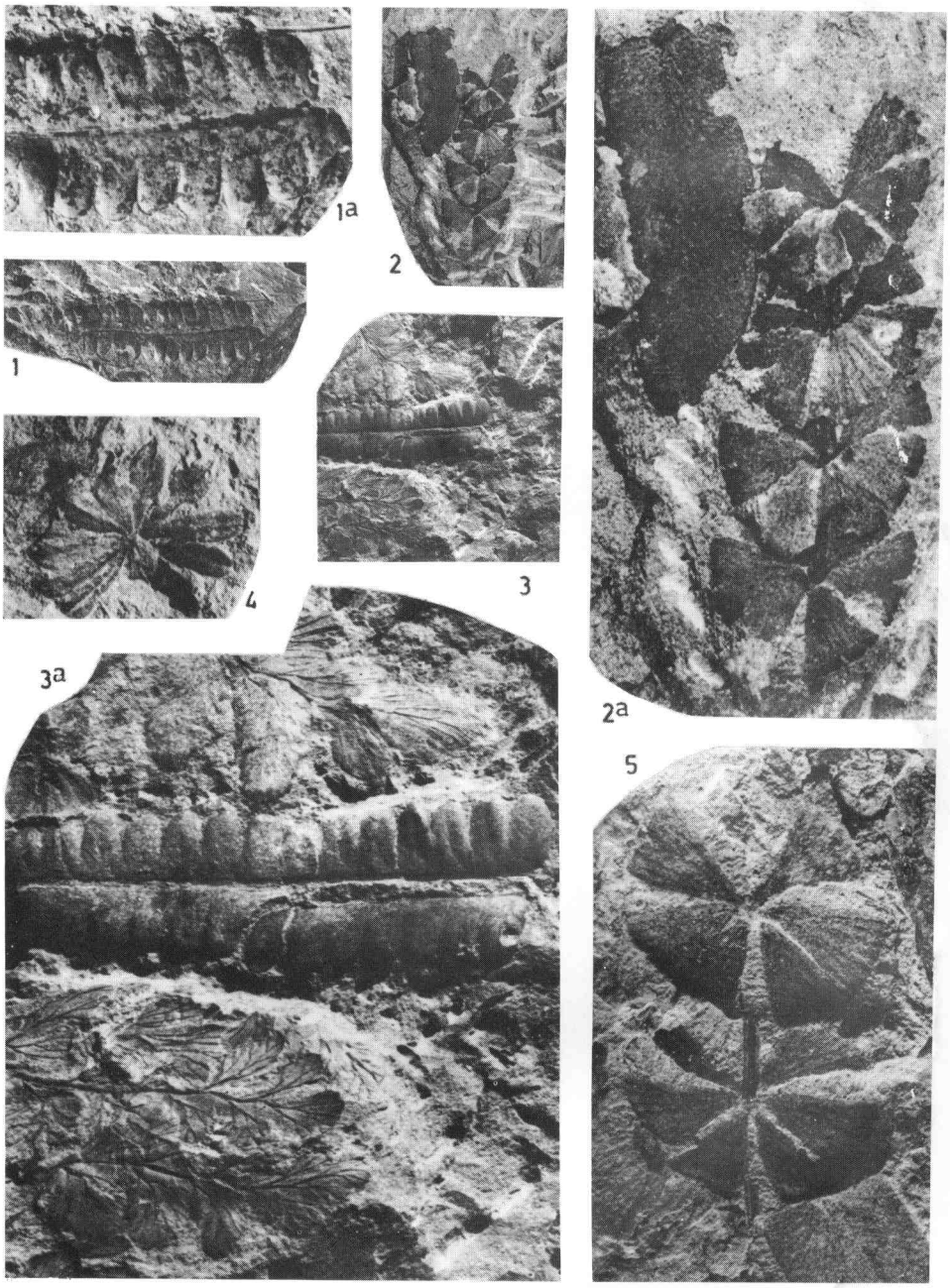
Fig. 2a.—The same specimen, × 3.

Fig. 3.—*Pecopteris unita* BRONGNIART and *Mariopteris (Fortopteris) latifolia (non* BRONGNIART?) ZEILLER, × 1. DPO 1184. Loc. 15 at Pumardongo, Olloniego Formation.

Fig. 3a.—The same specimen, × 3.

Fig. 4.—*Annularia sphenophylloides* (ZENKER) VON GUTBIER, × 3. DPO 1208. Loc. 12 near Malpica, Esperanza Formation.

Fig. 5.—*Sphenophyllum emarginatum* BRONGNIART, × 3. DPO 1132. Loc. 14 at Malpica, Olloniego Formation.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