DESCRIPTION OF AN EARLY PERMIAN FLORA FROM ASTURIAS AND COMMENTS ON SIMILAR OCCURRENCES IN THE IBERIAN PENINSULA

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TRABAJOS DE GEOLOGIA

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Drifted plant remains attributable to *Lebachia parvifolia* Florin, *Taeniopteris* cf. *fallax* Goeppert, cf. *Callipteris conferta* (Sternberg) and *Neuropteris* sp. have allowed dating the Villaviciosa beds of northern Asturias as probable early Permian. These beds consist of several hundred metres of sandstones, shales and limestone conglomerates. They overlie the Carboniferous with marked angular unconformity and are structurally a part of the post-Hercynian, generally Mesozoic cover. They are mainly red beds which have often been regarded as Triassic. Volcanic elements occur throughout. A general review of the history of investigations on the Permian of Asturias is accompanied by comments on the flora of Puente Bergueres (Patac 1920) and that of San Tirso in the earliest post-Hercynian strata near the northern edge of the Central Asturian Coalfield. The rather different assemblage from the Villaviciosa beds is figured and described. Comparisons are made with late Stephanian C and early Permian floras recorded elsewhere in the Iberian Peninsula. This includes a revised list of floral elements recorded from Buçaco in northern Portugal.

El hallazgo de *Lebachia parvifolia* Florin, *Taeniopteris* cf. *fallax* Goeppert, cf. *Callipteris conferta* (Sternberg) y *Neuropteris* sp. en las Capas de Villaviciosa permite datarlas como Pérmico inferior probable, modificando así la atribución al Triásico que se venía haciendo casi unánimemente. Estos estratos, discordantes sobre el Carbonífero, consisten en varios centenares de metros de areniscas, lutitas y conglomerados calcáreos. Predominan las tonalidades rojas y hay una aportación volcánica importante en esta formación que participa estructuralmente en la cobertera mesozóica del norte asturiano. Se alude a la historia de las investigaciones sobre el Pérmico asturiano, haciendo hincapié en las escasas dataciones paleontológicas. Se comentan los restos de flora considerada como Autuniense de Puente Bergueres, cerca de Pola de Siero que fueron figurados por Patac (1920), y se da una lista provisional de la flora recogida en la Formación San Tirso (Gervilla *et al* 1978), de edad probable Estefaniense C alto. Se describen los elementos de flora encontrados en las Capas de Villaviciosa, figurando los mismos. Finalmente se presentan comentarios sobre las floras pérmicas y del Estefaniense C alto dadas a conocer de otros lugares de la Península Ibérica, presentándose una lista de flora de Buçaco (Portugal), de acuerdo con una revisión actualmente en curso.

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The Permian of Asturias has posed problems in that it is mainly represented by red beds and that the dating of these deposits is entirely dependent on the rare finds of plant fossils. Most of these strata are unfossiliferous. The general facies is similar to that of the overlying Triassic which is also generally unfossiliferous, and the separation of these two units is often difficult despite the fact that they are mutually disconformable. No detailed sedimentological studies exist as yet on the Permian strata of Asturias, and the stratigraphic relationships are being unravelled only very slowly. The second author has taken an interest in the Permian stratigraphy of northern Asturias ever since rocks of this age appeared more commonly than was expected in the course of mapping for the 1 : 50,000 series of the Geological Map of Spain (Plan Magna). These rocks also appeared to be involved in a number of mineralisations in eastern and northern Asturias (Martínez García and Tejerina 1979).

The present paper is based primarily on the find of identifiable plant remains in sandstones of the Villaviciosa beds, a still informal rock unit established by the second author for strata underlying the Lias in northern Asturias. These strata were suspected of being of Permian age, but final proof awaited the find of identifiable fossils. The second author finally encountered plant remains which motivated a joint visit and the subsequent description of the floral remains by the first author, who identified a pre-Triassic, probably early Permian flora. The latter is taking the opportunity to present also a provisional list of plant fossils from the San Tirso Formation, a comparable rock unit which overlies the Westphalian C-D deposits of the Central Asturian Coalfield with the same degree of angular unconformity as is noted for the Villaviciosa beds and the underlying Viñón beds further north in Asturias. This list reflects investigations which are being carried out in collaboration with Professor J. P. Laveine of the University of Lille.

GENERAL REVIEW OF THE PERMIAN OR SUPPOSED PERMIAN IN ASTURIAS

The presence and, especially, the recognition of Permian strata in Asturias (Fig. 1) has been a problem compounded by the general similarity with overlying Triassic deposits and the extreme paucity of fossil remains capable of providing stratigraphic dating. Both the Permian and Triassic of Asturias are predominantly red beds of continental facies. They overlie the steeply folded Carboniferous and earlier Palaeozoic strata with strongly angular unconformity and thus participate in the Mesozoic cover rocks of Northwest Spain.

The author of the first geological map of Northwest Spain, Schulz (1858), mentioned the Permian in Asturias in error when he assigned the Carboniferous limestones of the Sueve Massif to this system. Barrois (1882, p. 59) stated his conviction that the Permian would be represented in northern Asturias, and based this on

Fig. 1.–Palaeozoic outcrops in the Iberian Peninsula with the location of the main Permian and upper Stephanian C occurrences.

the presence of tuffs («mimophyres») in a position unconformable on the Carboniferous and below and intercalated with beds attributed to the Trias by Schulz. No palaeontological arguments were provided but the beds attributed to the Permian by Barrois are, in fact, proving to be of Permian age. Adaro (1914) described the Permian of Viñón and Villaviciosa in northern Asturias but attributed them to the Triassic, again without palaeontological data.

The first palaeontological evidence of a possible Permian age was provided by Patac (1920), when he figured *Callipteris conferta* (Sternberg) Brongniart, *Walchia, Dicksonites* and *Pecopteris* which were obtained from an exploratory shaft at Puente Bergueres, near Pola de Siero. Interestingly, these plants came from steeply dipping beds overlain with angular unconformity by Cretaceous sediments. The stratigraphic relationships are rather different here since the beds at Puente Bergueres were obviously folded before the Mesozoic succession was laid down, whereas the Permian further north, near Colunga and Villaviciosa, is paraconformable with the Mesozoic. Patac's specimen of *Callipteris conferta* is well preserved and the identification is entirely convincing. The two scraps of conifer foliage figured by Patac and which he attributed to *Walchia hypnoides* (Brongniart) and *Walchia piniformis* (von Schlotheim), are probably unidentifiable specifically. The shaft at Puente Bergueres was abandoned and no further remains of fossils were recovered from this area (Patac 1956).

Karrenberg (1934) and Meléndez (1950, 1952) mapped a succession of red beds near Colunga, which they attributed to the Permian (Rotliegend) on general stratigraphic characteristics including the presence of volcanic deposits, and on its relative position in between Carboniferous and Liassic. A strongly angular unconformity separates this succession from the Carboniferous, whilst a low-angle unconformity separates it from the Liassic (Meléndez 1952). More recently, Forster (1974) also assigned the sediments associated with the fluorspar deposits of Pola de Siero, Colunga and Caravia to the Permian. He based this on the presence of certain fusulinid faunas and continental floras but failed to substantiate these records which are giving rise to considerable doubt, particularly with regard to the fusulinid limestones, which would seem more likely to be Carboniferous.

In the course of mapping the 1 : 50,000 Oviedo Sheet of the Geological Map of Spain, Gervilla and others (1978) encountered well preserved plant remains in the San Tirso Formation which lies with angular unconformity on the Carboniferous of the Central Asturian Coalfield. The locality is near the village of San Tirso, north of the main road from Mieres to Sama de Langreo (Fig. 2). The San Tirso For-

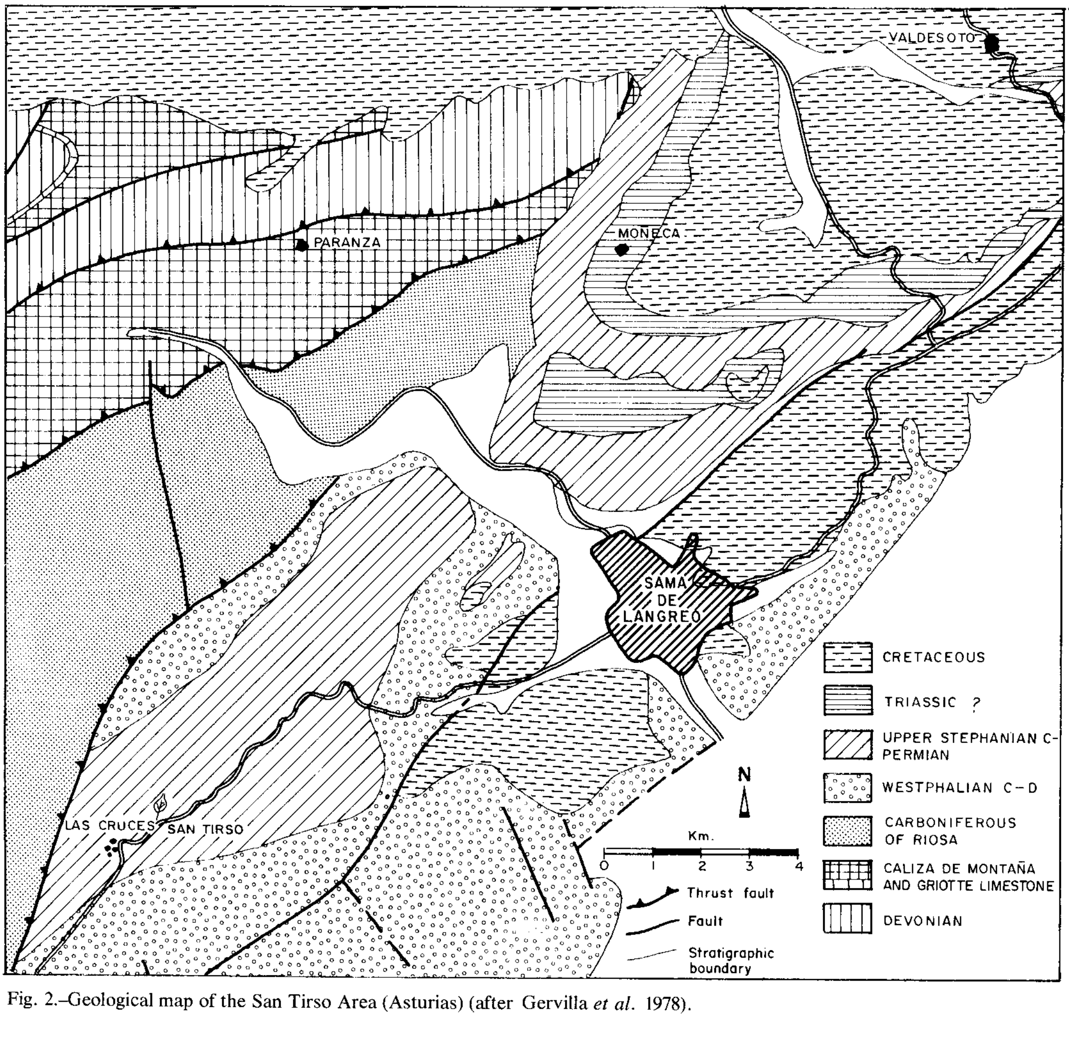


Fig. 2.–Geological map of the San Tirso Area (Asturias) (after Gervilla *et al.* 1978).

mation has been described as containing pyroclastic deposits intercalated with dark shales and sandstones in a succession which also comprises two limestone conglomerates. Dr. M. Gervilla kindly showed this locality to R. H. Wagner and J. P. Laveine who collected the following elements of flora (provisional identifications after a study which is still in progress): *Neuropteris neuropteroides* (Goeppert) Barthel, *Neuropteris praedentata* Gothan, *Neuropteris* cf. *zeilleri* de Lima, *Odontopteris brardi* Brongniart, *Callipteridium* cf. *gigas* (von Gutbier) Weiss, *Pseudomariopteris ribeyroni* (Zeiller) Danzé-Corsin, *Pseudomariopteris busqueti* (Zeiller) Danzé-Corsin, *Sphenopteris pachypteroides* Fontaine & White, *Sphenopteris* cf. *lescuriana* Fontaine & White, *Sphenopteris* sp. nov.?, *Pecopteris* spp., *Sphenophyllum oblongifolium* (Germar & Kaulfuss) Unger, *Annularia stellata* (von Schlotheim) Wood, *Annularia sphenophylloides* (Zenker) von Gutbier, *Cordaites* sp. The age of this flora is either late Stephanian C or early Autunian. Comparison can be made with Buçaco in Portugal, the Dunkard in the Appalachian region of North America, and, to some extent, with the 'Stephanian D' assemblages of southcentral France. The general assemblage is indicative of a warm, humid climate, and it is likely to be hypautochthonous (i. e. deposited near the site of growth).

In recent years, Martínez-García (1981) has described a probable Permian succession of unconformable shales, limestones, conglomerates and sandstones, all of apparent non-marine facies, in the central massif of the Picos de Europa. This is the Sotres Formation *(op. cit.)* which shows numerous associated mineralisations. This formation lies unconformably on upper Stephanian sediments and is covered in turn, also unconformably, by the Lower Triassic sediments of the Santander Basin*. Martínez-García and Tejerina (1979) showed the association of similar deposits of a supposed Permian age with fluorite mineralisations in central Asturias, and interpreted these red beds as deposits laid down in a continental rift system with associated volcanism and mineralisation.

However, most authors regarded these deposits as either Triassic or Permo-Triassic (e. g. Barrois 1882, Adaro 1914, Gervilla and others 1978, Sánchez de la Torre and others 1977).

THE PERMIAN OF ROTLIEGEND FACIES NEAR VILLAVICIOSA

Fieldwork by the second author has shown the presence of two lithological units in the general area of Villaviciosa in rocks unconformably overlying the folded Devonian and Carboniferous (Fig. 3). The lower rock unit, the Viñón beds (Martínez García, 1981) (Fig. 4), consists of c. 500 m of sandstones with barites veins, mudstones, volcanics, limestones and conglomerates. This unit is only present in certain areas and is absent in most places. It was originally described by Prado (1972) from the area near Viñón, north of the Central Asturian Coalfield. Most of the sediments in this formation show grey colours.

The upper rock unit, the Villaviciosa beds (Martínez García, 1981), consists of c. 600 m of sandstones, mudstones, conglomerates and volcanics (Fig. 4). The highest subunit is the Riera Conglomerate of Meléndez (1950). They are mainly red beds. In general terms the Villaviciosa beds show sandstones and shales with interbedded volcanics in the lower part, whilst sandstones, tuffs and conglomerates with a high limestone and tuff component characterise the upper part.

Some of the sandstones in the lower part of the Villaviciosa beds show abundant comminuted plant fragments among which larger remains occur occasionally. The first locality to yield identifiable plant remains is at 500 m north of the hamlet of Cueli, 5 km east of Villaviciosa (Fig. 3). These fossils are described in the present paper. They are identified as *Lebachia parvifolia* Florin, *Taeniopteris* cf. *fallax* Goeppert, cf. *Callipteris conferta* (Sternberg) Brongniart and *Neuropteris* sp. indet. Associated silicified wood fragments have not been identified.

The Villaviciosa beds are quite uniform in composition right up to the Riera Conglomerate, and it may be assumed that the Autunian age shown by the Cueli flora is applicable to the

* The unconformable strata at Sotres have recently yielded plant impressions to the second author. They indicate an Autunian age (R. H. Wagner *det.): Callipteris conferta* (Sternberg), *Dicksonites leptophylla* Doubinger (= *Pecopteris leptophylla* Zeiller *non* Bunbury), *Sphenopteris* cf. *minutisecta* Fontaine & White, *Pecopteris hemitelioides* Brongniart, *Sphenophyllum* cf. *miravallense* Vetter, *Annularia stellata* (von Schlotheim). (Note added while the paper was in press).

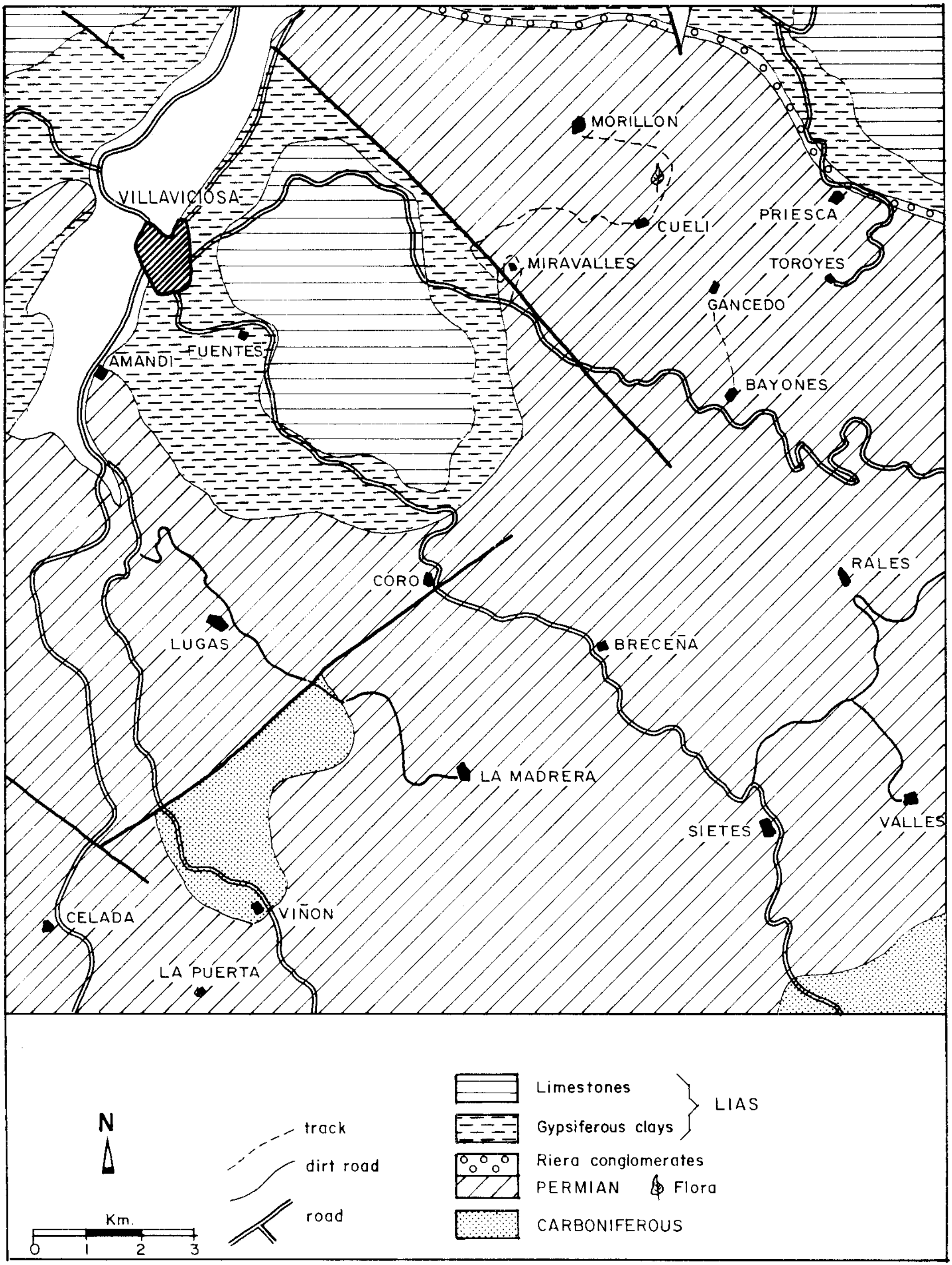


Fig. 3.–Geological map of the Villaviciosa Area (Asturias).

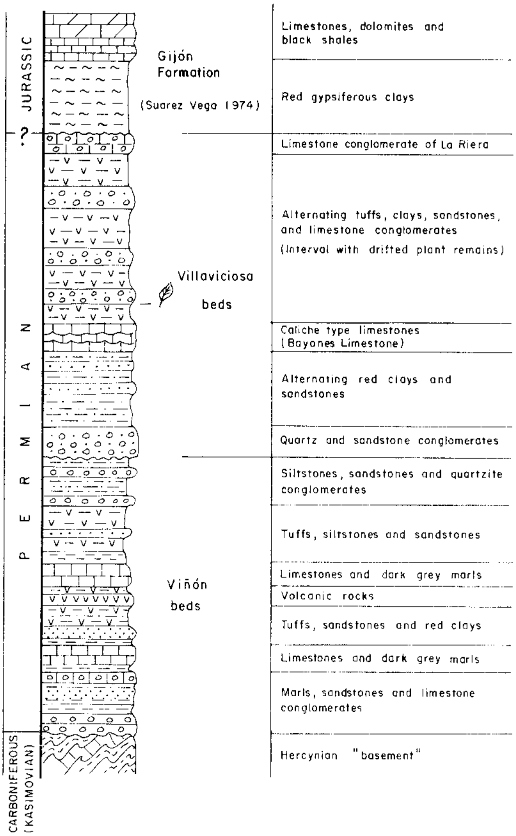


Fig. 4.–Stratigraphic section of the Permian in the Villaviciosa Area (after Martínez García, 1981).

entire sequence. Above the Riera Conglomerate in the Colunga area several tens of metres of red and green clays with gypsum and quartz crystals separate the Villaviciosa beds from the overlying Liassic dolomites. Patac (1920) assumed these clays to be a Zechstein equivalent, but the recent work by Palain (1968) in northern Portugal allows a comparison with the Liassic. They are, in fact, undated.

The Villaviciosa beds are lithologically similar to the Autunian (or upper Stephanian C ?) Labra Formation of northern Palencia (Jong 1971, Maas 1974).

DESCRIPTION OF THE FLORAL REMAINS NEAR CUELI

These occur as imprints and carbon stains on light coloured, yellowish brown, fine to medium-grained sandstones with mud partings. The sandstones are thinly bedded with parallel and cross lamination. Cross bedding has also been seen. The plant remains are mainly finely comminuted and cover the closely spaced bedding planes in considerable profusion. Occasional larger fragments are mainly branches and branchlets of the conifer *Lebachia parvifolia* Florin. These conifer remains show up as carbonised vegetable matter without an apparent cuticle. One may assume that the rather fleshy leaves of the conifer were resistant to decay and subsequent transport in what appears to have been a fluviatile medium. A single poorly preserved fragment of a probable *Callipteris conferta* (Sternberg) Brongniart shows only the general outline of pinnules on rachides of the last and penultimate orders. Only the general inclination of the veins can be determined on a few of the pinnules. The lacerated fragment of a large *Taeniopteris* leaf is accompanied by fragments of smaller leaves which belong most likely to the same species, here identified as *Taeniopteris* cf. *fallax* Goeppert. A single pinnule fragment of *Neuropteris* shows a veining pattern and density comparable to *Neuropteris neuropteroides* (Goeppert) Barthel, but is too fragmentary for a reliable identification. A few silicified wood fragments have also been found.

These plant remains obviously constitute a drifted assemblage. Its composition is likely to owe a good deal to the resistence to maceration and transport in flowing water, and it may be assumed that more fragile species are not represented because of comminution under fluviatile conditions.

Is also noted that the identified species all belong to the *Callipteris*-*Walchia* Association of Gothan & Gimm (1930), which consists of non-swamp elements. These plants would have lived on the higher ground, with better drained soils.

Lebachia parvifolia Florin
Fig. 5 d-f; Fig. 6 d

Description.–Several branch fragments showing spreading lateral branchlets (at c. 60°) in an apparently subopposite arrangement. Leaves extensively overlapping, inserted at a narrow angle (though not fully adpressed to the branch), with a fleshy, somewhat keeled base and tapering gradually to a point; leaves straight over most of their length but curving inwards near the tip. The larger leaves are 4-5 mm long with an apparent basal width of 1 mm.

Discussion.–The holotype of *Lebachia parvifolia* originates from the Stephano-Permian deposits of Buçaco, near Coimbra, Portugal. Originally figured in Palaeontographica (Florin, 1938-39, Tafs XXXI-XXXII, Figs. 1-3), it was refigured by Florin in 1940 (pl. II, Figs. 1-3). The present material is too fragmentary to show the verticillate arrangement of the main branches, but it does display the mostly parallel, two-ranked, alternate or subopposite arrangement of ultimate branches as referred to in Florin's description. However, the identification is mainly based on the shape and arrangement of leaves on the ultimate branches or branchlets which Florin (1940) describes as follows (loc. cit., p. 4-5): «Branchlets characterized by a much thinner axis (in comparison with the middle and basal parts of foliage-shoots of penultimate order), up to 10 cm long, their basal and middle portions including the leaves from 2 to 5.5 mm in diameter, flexible, more or less densely covered from base to apex by homomorphic, bifacial, spirally disposed, overlapping, probably firm, more or less S-shaped leaves, which for the most part are concave adaxially and then either hardly curved at all or else curving gradually inwards up to 40° at the apex. These leaves from 2 to 4.5 (very occasionally to 5) mm long, gradually decreasing in length towards the end of the branchlets and also towards the distal region of the lateral shoot systems, 0.7-1.2 mm broad at the base, mostly 0.2-0.4 mm thick halfway to the apex, more or less spreading, broadly decurrent, very narrowly triangular or almost linear in face view, tapering to an acuminate, never bifid apex, slightly keeled on both surfaces, and in all probability uninerved. Bud scales absent».

This most detailed description fits the branchlets found at Cueli. Indeed, the dense arrangements of decurrent, rather fleshy leaves with incurved tips appear identical in Florin's type and the material at hand. Florin's photographs also show the acute angle at which the spirally disposed leaves are inserted on the branchlets, and this is very similar to the attitude of the leaves in the specimens from Cueli.

Taeniopteris cf. *fallax* Goeppert
Fig. 5 b-c; Fig. 6 a-c

Description.–A fragment of a very large leaf, at least 14 cm wide at a position corresponding apparently to the upper part of the leaf a little above its maximum width, is accompanied by fragments of much smaller leaves including one showing a nearly basal part. The latter seems to have been only about 3 cm wide. All fragments show the same pattern and density of veining. A wide midvein (almost 4 mm wide in the basal fragment of one of the smaller leaves) tapers very gradually upwards but remains wide in the upper part of the leaf (1 to 3 mm). Lateral veins straight, parallel, and arching away from the midvein almost immediately to adopt a course at approximate right angles to the leaf border. Vein density c. 40 veins per cm. Veins once bifurcate near the midvein or, possibly, simple in part.

Discussion.–There are not many described species of *Taeniopteris* which show widths in the range of 14 cm as observed in one of the specimens at hand. This implies a possible length of 30 to 50 cm which is very considerable. The dense parallel veining with an apparent paucity of vein bifurcations also narrows the choice to only a few species. Remy and Remy (1975) produced a table stating the various characteristics (including size) of the different Late Palaeozoic species of *Taeniopteris*. It is a known fact that the range of variation in the size of leaves is very considerable within the individual species of *Taeniopteris* and that the venation becomes wider in the smaller leaves. The isolate nature of the majority of *Taeniopteris* records has probably resulted in a larger number of species having been described than might have been the case if a full range of specimens were known from each locality. Leaf size is regarded as a less reliable characteristic than the veining pattern and density, particularly in the case of relatively large leaves which are likely to retain approximately the same vein density in leaves of different sizes.

Among the European species of *Taeniopteris* of Late Palaeozoic age it is *Taeniopteris fallax* Goeppert which offers the greatest similarity. It has the same vein density (c. 40 per cm according to Halle (1927, p. 157), who reexamined the type) and it also shows rather broad leaves, albeit not quite as broad as the largest of the specimens in hand. Goeppert (1864-65, pp. 130-131) described the lateral veins as rarely simple and generally once bifurcate near the midvein. This seems to agree with the vein pattern of the Asturian specimens. The type (Goeppert's pl. IX, Fig. 3), as designated by Halle (1927), also displays straight, parallel veins as appear in the specimens at hand. Halle (1927) mentioned that *Taeniopteris smithi* Lesquereux and *Taeniopteris densissima* Halle were possible synonyms of *Taeniopteris fallax*. The former is a North American species and the latter has been described from the Permian of northern China.

Taeniopteris fallax was placed in synonymy with *Taeniopteris multinervis* Weiss by Zeiller (1894) who remarked upon the range of variation within this species. However, Weiss (1869, p. 99), when establishing the latter species, distinguished it from *Taeniopteris fallax* by its twice bifurcate lateral veins and extremely wide midvein. He also compared with *Taeniopteris abnormis* von Gutbier, another species with large leaves showing a fine, parallel nervation perpendicular to the leaf margin. Barthel (1976, p. 102) has placed *Taeniopteris multinervis* in synonymy with *Taeniopteris abnormis* von Gutbier (the latter was established in 1849) and illustrated several specimens showing the repeated vein bifurcations as well as the variable angle at which the lateral veins depart from the midvein. This variation is also visible on the Asturian specimens, the basal part of a leaf as figured on Fig. 6 b and Fig. 5 c, displaying a more oblique insertion of the lateral veins whereas the large specimen of Fig. 5 b and Fig. 6 a, shows a more immediately perpendicular position of the lateral veins to the midvein. A similarly perpendicular position of the veins is displayed by the smaller specimen figured on Fig. 6 c. The apparent absence of repeated bifurcations of the lateral veins makes the attribution to *Taeniopteris fallax* more appropriate than the possible identification with *Taeniopteris abnormis*. However, the rather poor preservation prevents a reliable observation of vein bifurcations, and the identification must therefore be tentative. In case the three species, *Taeniopteris abnormis* von Gutbier, *Taeniopteris fallax* Goeppert and *Taeniopteris multinervis* Weiss should prove to be one and the same (for which more complete material should be available), the specimens in hand would have to be assigned to *Taeniopteris abnormis* which has priority.

Taeniopteris multinervis Weiss has been recorded, with a single specimen, from the Stephanian C of the Paulina Formation in the Villablino Coalfield in León (Wagner, 1964, p. 842, pl. III, Fig. 34).

Cf. *Callipteris conferta* (Sternberg) Brongniart
Fig. 5 a

Description.–A small fragment of a pinna of the penultimate order shows pinnae at c. 45° insertion. The pinnules are also inserted obliquely, and show a decurrent base which appears narrowly confluent with adjacent pinnules. On the catadromous side of the pinnae of the last order a pinnule descends onto the penultimate rachis, thus occupying an intercalated position between pinnae. Pinnules ribbon-shaped, with a broadly rounded apex. The venation is hardly discernible but appears steeply inclined (as may be seen under immersion by alcohol).

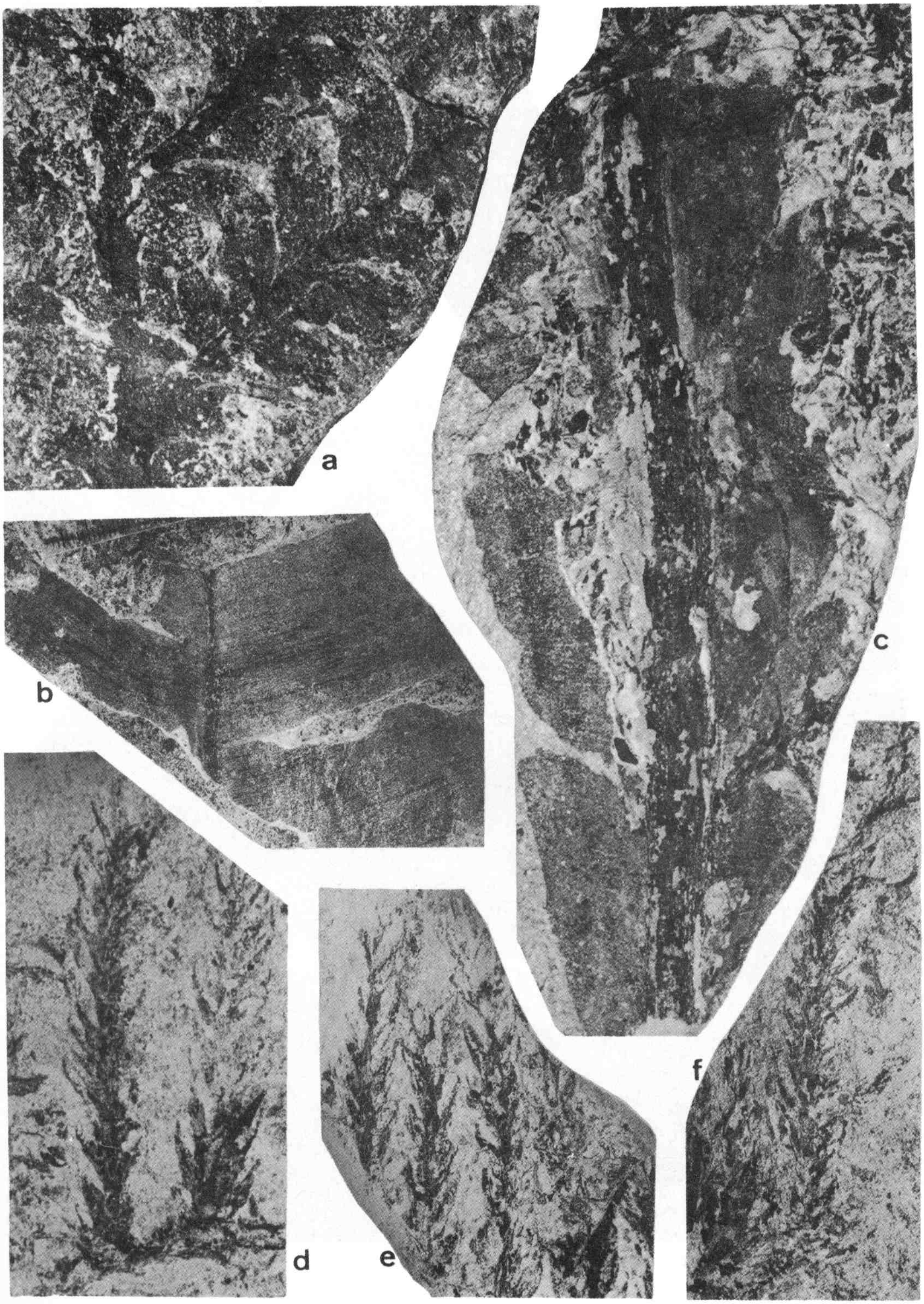
Discussion.–Whatever can be seen of this poorly preserved specimen conforms to the recent figuration of *Callipteris conferta* by Barthel and Haubold (1980). This includes topotypes. The positioning and shape of the pinnules and the presence of an intercalated pinnule on the penultimate rachis are all characters conforming to *Callipteris conferta*. However, the absence of a clearly discernible venation makes the identification not wholly reliable.

Callipteris conferta has been figured previously from Asturias by Patac (1920), who obtained a well preserved specimen from the exploratory shaft at Puente Bergueres, near Pola de Siero.

AGE OF THE FLORAL REMAINS NEAR CUELI

Lebachia parvifolia has been recorded from both the late Stephanian and the earliest Permian (Florin, 1940). The presence of lebachian conifers is conditioned mainly by edaphic and transport factors, and cannot be used as a reliable guide to an exact stratigraphic age.

Fig. 5.–a) cf. *Callipteris conferta* (Sternberg) Brongniart (x 3); b) *Taeniopteris* cf. *fallax* Goeppert (x 1); c) *Taeniopteris* cf. *fallax* Goeppert (x 3); d, e, f) *Lebachia parvifolia* Florin (x 3).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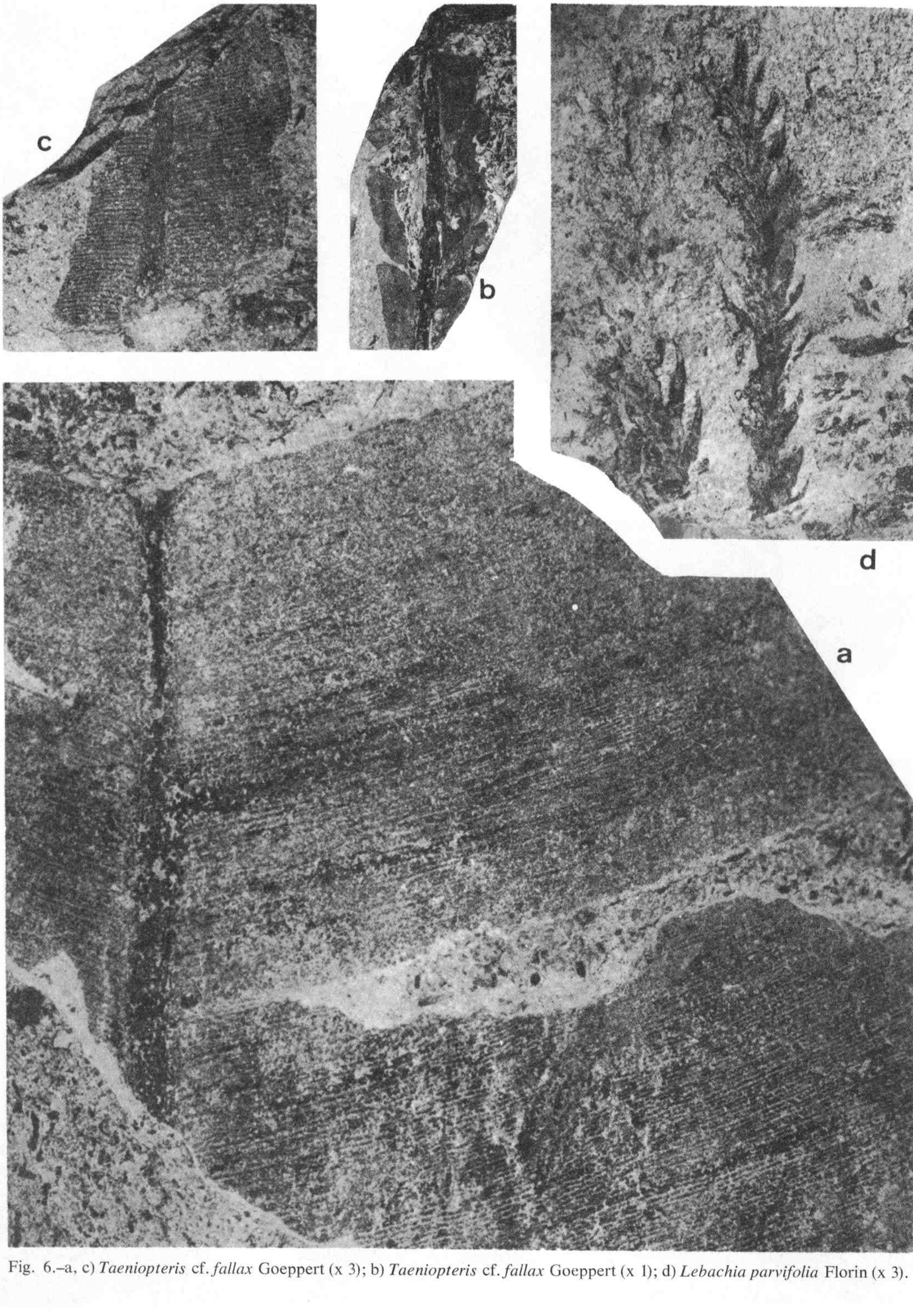

Fig. 6.–a, c) *Taeniopteris* cf. *fallax* Goeppert (x 3); b) *Taeniopteris* cf. *fallax* Goeppert (x 1); d) *Lebachia parvifolia* Florin (x 3).

Taeniopteris fallax is stated as part of the flora of the Millery and Surmoulin beds in the Autun Basin of central France (Bouroz and Doubinger, 1977). This is the upper Autunian in its type area. The similar species *Taeniopteris multinervis* appears earlier, i.e. from Stephanian C onwards.

Callipteris conferta is recorded sporadically from Stephanian C onwards (i.e. the Beaubrun Beds of the St. Etienne Basin – Bouroz and Doubinger, 1977), but is most common in the Autunian. Again, there is an element of edaphic control since it forms part of the *Callipteris-Walchia* Association of Gothan and Gimm (1930) which apparently lived on drier soil.

Although the number of species found near Cueli is rather small, it seems likely that the assemblage represents the Autunian. It is noted that the much richer flora obtained from the San Tirso Formation near the northern edge of the Central Asturian Coalfield, shows an assemblage of predominantly ferns and seed ferns representing a different habitat. The age of the latter is probably late Stephanian C (i.e. Stephanian D of Bouroz and Doubinger, 1977), an indication to this effect being given by the presence of *Neuropteris neuropteroides*. Although a direct comparison between the San Tirso and Cueli floras is hampered by the fact that two different habitats are represented (with an added complication due to the transported nature of the remains near Cueli), it is tempting to assume that the Cueli flora is somewhat later in age than that of San Tirso. The presence of *Taeniopteris* cf. *fallax* provides a weak indication to this effect. Further discoveries of floral remains and the aid of palynology will be required to date the Villaviciosa beds more exactly. For the time being, these beds are here regarded as Autunian in age.

COMPARISONS WITH OTHER AREAS IN THE IBERIAN PENINSULA

Sopeña, Doubinger and Virgili (1974) reported an Autunian flora, including *Callipteris conferta* and *Odontopteris* cf. *gimmi* Remy, from an unconformable succession of strata at Tamajón on the southern flank of the Central Mountain System NNE of Madrid. The underlying rocks are folded Lower Palaeozoics and the overlying deposits, also unconformable, are of Tertiary age. Cretaceous rocks in the near vicinity are reported as being in faulted contact with the Lower Permian. A complete account of the stratigraphy of this region comprising the area around the villages of Tamajón, Retiendas and Valdesotos, has been published by Sopeña (1979), who also figured macro-and microfloral remains obtained from the Retiendas sandstone unit. They indicate an Autunian age and include *Callipteris conferta*, *Callipteris raymondi* Zeiller, *Odontopteris (Mixoneura)* of the *O. lingulata* Goeppert group, *Pecopteris* spp, *Sphenophyllum angustifolium* Germar, *Annularia spicata* von Gutbier, etc. A little to the northeast within the same Central System, the Permian deposits at Pálmaces are assigned this age on stratigraphic comparison and on their unconformable position with regard to both the Lower Palaeozoic and the Triassic (Sopeña and others, 1977). The presence of *Estheria tenella* Jordan in unit 4 of the succession at Pálmaces de Jadraque has been taken to confirm an Autunian age (Sopeña 1979). Whereas this is correct in comparison with the Triassic, the stratigraphic range of *E. tenella* does in fact extend down into the upper Stephanian. Further north, in the Iberian Chain, the presence of Autunian strata, unconformable on Lower Palaeozoic rocks, has been proved by means of microflora (Ramos, Doubinger and Virgili, 1976). The presence of *Lebachia piniformis* (von Schlotheim) has also been recorded in the same general area west of Molina de Aragón, province of Guadalajara (Ramos, 1979). Further northeastwards, in the Aragonese part of the Iberian Chain, at Sauquillo, a locality with Autunian flora has been described from a succession of only 7 m of strata unconformable on Tremadoc and overlain with low angle unconformity by Triassic (De la Peña and others, 1977). Some of the identifications appear questionable, particularly those relating to the assumed presence of gigantopterids, but the illustrations suggest the presence of *Lebachia*, *Callipteris conferta* and *Fascipteris*. Records from the Pyrenees have been summarised by Sopeña and others (1977). Some remains of Autunian flora from Lérida were figured by Menéndez Amor (1952), and a recent paper by Doubinger, Robert and Broutin (1978) has shown the presence of *Lebachia piniformis* (von Schlotheim) Florin, *Walchia (?Ernestiodendron) germanica* Florin, *Ernestiodendron filiciforme* (von Schlotheim) Florin and *Ullmannia frumen-*

taria (von Schlotheim) Goppert near Ogassa (Gerona province), in the eastern Pyrenees.

It is noted that the floras recorded from the Autunian deposits in northern Spain are all fragmentary and generally comparable to the Rotliegend floras of northern Europe and to the Autunian floras of similar facies in south-central France. These Autunian strata are invariably in high angle unconformity with a range of earlier Palaeozoic rocks and form part of the post-Hercynian cover. The presence of volcanic material in these strata constitutes a characteristic feature. Sopeña and others (1977) stress that these Autunian strata are mainly grey beds with occasional coal smuts, even though red beds are intercalated in places. These strata are overlapped by a red bed succession, attributed to the Saxonian on the basis of a comparison with south-eastern France (op. cit.). In one locality of the Iberian Chain these overlying red beds have yielded a Late Permian microflora (Boulouard and Viallard, 1971).

A more complete floral assemblage is known from the intramontane basin of Buçaco, near Coimbra, in northern Portugal. The most recently published list from this basin is due to Teixeira (1944) who has revised earlier work. The stratigraphy and floral contents of the terrestrial deposits of the Buçaco Basin are currently being revised by R. H. Wagner and M. J. Lemos de Sousa. The basin is being mapped in detail by F. Gomes da Silva, of the University of Coimbra. Most of the deposits in this basin are red beds with a high proportion of mass-transported coarse conglomerates which, in the lower part of the succession, are accompanied by mud flow deposits. Most of the abundant plant fossils known from the Buçaco Basin have been collected from a grey interval containing a single, thin coal seam. The following list corresponds to the current revision of the flora from Buçaco by R. H. Wagner and M. J. Lemos de Sousa: *Neuropteris neuropteroides* (Goeppert) Barthel, *Neuropteris zeilleri* de Lima, *Neuropteris planchardi* Zeiller, *Neuropteris praedentata* Gothan, *Neuropteris* sp., *Linopteris gangamopteroides* (de Stefani) Wagner, *Odontopteris brardi* Brongniart, *Odontopteris osmundaeformis* (von Schlotheim) Brongniart, *Lescuropteris genuina* (Grand' Eury) Remy, *Callipteridium gigas* (von Gutbier) Weiss, *Callipteridium densinervium* Wagner (ex *regina* Zeiller, non Roemer). *Alethopteris zeilleri* Ragot, *Dicksonites leptophylla* (Zeiller) Doubinger, *Pseudomariopteris ribeyroni* (Zeiller) Danzé-Corsin, *Pseudomariopteris busqueti* (Zeiller) Danzé-Corsin, *Taeniopteris multinervis* Weiss, *Taeniopteris jejunata* Grand' Eury, *Oligocarpia bredovii* (Germar), *Oligocarpia leptophylla* (Bunbury) Grauvogel-Stamm and Doubinger, *Sphenopteris cremeriana* Potonié, *Eusphenopteris rotundiloba* (Němejc) van Amerom. *Nemejcopteris feminaeformis* (von Schlotheim) Barthel, *Pecopteris unita* Brongniart, *Polymorphopteris polymorpha* (Brongniart) Wagner, *Lobatopteris viannae* (Teixeira) Wagner, *Pecopteris cyathea* (von Schotheim) Brongniart, *Pecopteris limai* Teixeira, *Pecopteris bussacensis* Teixeira, *Pecopteris densifolia* (Goeppert), *Pecopteris longipinnata* Teixeira, *Pecopteris* spp., *Sphenophyllum thoni* (von Mahr), *Sphenophyllum angustifolium* Germar, *Sphenophyllum oblongifolium* (Germar and Kaulfuss) Unger, *Sphenophyllum costae* Sterzel, *Annularia stellata* (von Schlotheim) Wood, *Annularia sphenophylloides* (Zenker) von Gutbier, *Asterophyllites equisetiformis* (von Schlotheim) Brongniart, *Asolanus camptotaenia* Wood, *Cordaites* sp., *Lebachia parvifolia* Florin, *Lebachia laxifolia* Florin, *Lebachia goeppertiana* Florin and rare *Callipteris conferta* (Sternberg). This assemblage is of late Stephanian C age (i.e. Stephanian D of Bouroz and Doubinger, 1977). It may be compared to the flora of San Tirso in Asturias. *Neuropteris neuropteroides* is a particularly important element in common between both assemblages. The Buçaco Basin differs from the other areas of late Stephanian C – Autunian ages in the northern part of the Iberian Peninsula in that it lacks the volcanic elements which form such a prominent characteristic of the latter.

The most comprehensively studied early Permian flora of the Iberian Peninsula is at Guadalcanal (province of Sevilla) and nearby Fuente del Arco (province of Badajoz), in south-western Spain. Broutin (1974 a, b, 1977, 1981) has recorded over 80 species of macroflora from this area, as well as 85 genera of microflora. Different levels of a relatively small total succession (only a few tens of metres thick), and which is unlikely to represent more than a single age have yielded plant assemblages of rather different composition. Broutin's detailed analysis shows the presence of Cathaysian and Angaran taxa in association with Euramerian forms of the classic «coal-measure» and «Rotliegend» facies. A late Autunian to Saxonian age has been regarded as most likely. This makes the flora of Guadalcanal much later in age than those of Buçaco and San Tirso, though not necessarily later than that from Cueli. Among the standard Euramerian forms recorded from Guadalcanal and Fuente del Arco are the following (after Broutin 1981, which supersedes the earlier papers mentioned above): *Callipteris conferta* (Sternberg) Brongniart, *Lebachia piniformis* (von Schlotheim) Florin, *Lebachia hypnoides* (Brongniart) Florin, *Lebachia frondosa* (Renault) Florin, *Ernestiodendron filiciforme* Florin, *Walchia (?Ernestiodendron) germanica* Florin, *?Ullmannia bronnii* Goeppert, *Taeniopteris* cf. *multinervis* Weiss, *Odontopteris (Mixoneura) subcrenulata* (Rost) Weiss, *Neuropteris (Mixoneura) auriculata* (Brongniart) Broutin, *Eusphenopteris rotundiloba* (Němejc) van Amerom, *Sphenopteris lebachensis* Weiss, *Sphenopteris matheti* Zeiller, *Sphenopteris elaverica* (Zeiller) Alvarez Ramis, *Schizostachys pinnata* (Renault) Barthel, *Schizostachys hispanica* Broutin, *Pecopteris* ex gr. *arborescens* (von Schlotheim) Brongniart, *Pecopteris paleacea* Zeiller, *Pecopteris pseudo-oreopteridia* Potonié sensu Vetter, *Pecopteris unita* Brongniart, *Pecopteris (Lobatopteris) vestita-lamuriana* (Lesquereux-Heer), *Polymorphopteris polymorpha* (Brongniart) Wagner, *Sphenophyllum oblongifolium* (Germar & Kaulfuss) Unger, *Sphenophyllum verticillatum* (von Schlotheim) Zeiller, *Sphenophyllum* cf. *emarginatum* Brongniart, *Annularia stellata* (von Schlotheim) Wood, *Annularia sphenophylloides* (Zenker) von Gutbier, *Annularia spicata* von Gutbier, *Asterophyllites equisetiformis* (von Schlotheim) Brongniart, *Asterophyllites longifolius* (Sternberg) Brongniart, *Calamites suckowii* Brongniart, *Sigillaria brardii* Brongniart, *Cordaites laticrassinervis* Broutin, *Cordaites* cf. *regularis* Ledran, *Poacordaites* spp. It has been noted that the conifers and the ferns occurred in different beds. Changes in the local climate have been evoked to account for this. Broutin also discussed the effect of different habitats. Several more unusual elements also occurred sporadically. These are the probable ginkgophytes *Rhipidopsis baetica* (Broutin) Broutin, *Rhipidopsis* cf. *ginkgoides* Schmalhausen, *Ginkgoites* sp, *Ginkgophyllum boureaui* Broutin, *Ginkgophytopsis* sp. aff. *G. kidstonii* (Seward) Høeg. These elements would seem to be more at home in the Cathaysian Permian floras and this impression is reinforced by the following species found by Broutin (1981): *Psygmophyllum* sp. aff. *P. multipartitum* Halle, *Pelourdea* sp., *Protoblechnum (Compsopteris) wongii* Halle, *Cordaites* cf. *schenkii* Halle, *Sphenopteris pseudogermanica* Halle, and *Lobatannularia* sp. Broutin (1974 b, 1981) also described *Koretrophyllites crassinervis* Broutin, *Phyllotheca* sp. and *Phynadaeopteris anthriscifolia* (Goeppert) Radczenko, of Angaran affinity. The presence of a more varied floral association in the Permian deposits of Guadalcanal, in comparison with those found in northern Europe and, indeed, in the northern part of the Iberian Peninsula, may be ascribed to either migration from the Cathaysian Realm Ria the Middle East and North Africa or to the development of relatively drier and more humid areas in the broadly equatorial belt of Permian times. Broutin (1981) appears generally in favour of migratory links, whereas one of the present authors (RHW) regards the climatic factor as being most important. The development and gradual extension of relatively dry areas within the equatorial belt (sensu lato) in the course of latest Carboniferous and, particularly, Permian times, seems to have been a worldwide phenomenon leading to a pattern of floral distribution which may well be related to precipitation patterns. The later early Permian floras of the Iberian Peninsula seem fo reflect the transition from a more humid area in the south (Guadalcanal) to a drier area in the North (Cueli), the latter being similar in this respect to North European localities (France, Germany, etc.)

Broutin (1981) has speculated on the importance of the Porto-Badajoz-Córdoba fault zone in Permian times. Whereas the significance of this fracture zone in earlier Paleozoic times is undeniable it is not clear from the paleobotanical evidence that it provided a separation between different parts of the later Iberian Peninsula during Permian times. In fact, the large number of identical and similar species found at Guadalcanal and in the Iberian Chain would tend to suggest a transition between the southern and northern regions. It is also fair to state that the considerable detail at which the flora from Guadalcanal and Fuente del Arco has been recorded, has not yet been matched elsewhere in the Iberian Peninsula.

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