9. *On a COLLECTION of CARBONIFEROUS PLANTS from PERU.*¹
By Prof. ALBERT CHARLES SEWARD, Sc.D., F.R.S., Pres.G.S.
(Read April 12th, 1922.)

[PLATE XIII.]

IN the course of a geological expedition to Peru in 1911 Mr. J. A. Douglas collected some fossil plants from coal-bearing strata on the south side of the peninsula of Paracas, a few miles south of the port of Pisco (lat. 13° 45' S.). The plants, which are the property of the Geological Department of Oxford University, were handed to me for identification by Mr. Douglas, who also supplied information on the geology of the district. The specimens, though fragmentary and few in number, are worth recording, since this is the only known occurrence of fossiliferous Palæozoic rocks on the coast of Peru.² Moreover, from a phytogeographical point of view, any fossil plants from South America are worthy of attention.

The coal occurs in a series of greenish sandstones and grey and black carbonaceous shales, which have a north-easterly strike and dip about 25° south-eastwards. These are overlain unconformably on the neck of the peninsula by Tertiary sandstones and impure limestones. There is no definite stratigraphical evidence of the age of the coal-bearing beds, and the plants are therefore of special importance: in other districts the strata which are the chief source of Peruvian coal are Mesozoic in age. Mr. Douglas informed me that the rocks in question were described by Friedrich Fuchs,³ who published a note on them in 1900 in the 'Boletín de Minas' (Lima). Fuchs recorded the following species, and assigned the beds to the Upper Coal Measures:—

<i>Calamites Suckowi</i> Brongniart.	C.	<i>Lepidodendron Sternbergii</i> Brongniart.	C.
<i>Sphenopteris Hartlebeni</i> Dunker.	W.	<i>Sigillaria tessellata</i> Brongniart.	C.
<i>Baiera pluripartita</i> Schimper.	W.	<i>Stigmaria ficoides</i> Brongniart.	C.

Four of these species (C) are well-known Northern Hemisphere Carboniferous plants and two (W) are Wealden species. It is obviously impossible to express an opinion on the nature of Fuchs's specimens. A short account of the geology of the district is given by Mr. V. F. Marsters, who states that Fuchs mapped the whole area as Carboniferous, the plants being typical Carboniferous species: the fact that two species are characteristic of European

¹ After this note had been sent to the Geological Society, a preliminary paper on 'Carboniferous Plants from Peru' by E. W. Berry, to be followed by a fully illustrated account, was published in the 'American Journal of Science' ser. 5, vol. iii (1922) p. 189. Mr. Berry's conclusion is that the Paracas plant-beds 'correspond to the Westphalian stage.'—[A. C. S.]

² Douglas (21) p. 250. Numerals in parentheses refer to the Bibliography, p. 283.

³ This paper has not been seen, either by Mr. Douglas or by myself.

Wealden floras was not noticed. The account of the geology of the district by Marsters is as follows:—

‘The geology of this district was studied by Don Federigo Fuchs, and according to his map the whole area is Carboniferous. The area termed Cerro de la Mina is occupied by Carboniferous strata, as the fossil flora indicates; the plants are typical species of the Carboniferous Period. The best exposure of the beds is to be seen on the coast between the house of the Director of the Exploration Company and the Punta de Huaca. This shows thick beds of sandstone with thin and fissile shales, the coal being associated with the shales; local folding, attenuation, and pinching-out of the seams are common phenomena. The dip of the strata varies in direction from S. 40° E. to S. 45° E., at angles between 16° and 27°. If we examine also the north-western boundary of the Cerro de la Mina on the south-eastern slope of the little valley of the Arquillo, we observe the same lithological conditions as in the former region. The Carboniferous strata are clearly in contact with rocks which are, without any doubt, Tertiary. In many places the shales are very carbonaceous, containing at times thin lenticles of pure coal. The dip of the beds varies from 16° to 20°; the whole formation is inclined towards the south-east.

‘After having visited this region, Señor Bravo states that west of the Cerro de la Mina Carboniferous sediments exist in the neighbourhood of the Punta de Lechuza.’¹

To Mr. Douglas I am also indebted for the following extract from a paper by Prof. C. I. Lisson (13):—

‘In the year 1900 Prof. Fuchs published the discovery of a Carboniferous flora situated on the peninsula of Paracas. Although a revision of the determinations adopted by Fuchs is necessary, nevertheless it is a proved fact that the plants show decisively the presence of a Carboniferous deposit.’

Here again is no reference to the fact that Fuchs’s list included some typical Wealden plants.

In view of the inclusion of two Wealden species in the list of plants given by Fuchs, it is noteworthy that the occurrence of a Wealden flora was recorded in Peru in 1907 and 1910.²

A photograph of the coal-bearing beds on the Pacific coast is published in a book by R. Enock³ on the Andes and the Amazon: this author speaks of the coal-deposits of Peru as one of the country’s most valuable assets. These carbonaceous deposits are of Mesozoic, and not of Palæozoic age.

So far as I am aware, no Upper Carboniferous flora, in which are not included members of the *Glossopteris* flora, has been described from South America.

Description of the Specimens.

SPHENOPTERIS sp. (Pl. XIII, figs. 1–3.)

The collection includes several fragments of pinnæ, pieces of rachis, and pinnules of a fern-like plant, although these are unfortunately not sufficiently well preserved to be identified with

¹ Marsters (09) pp. 40–41. This extract is taken from a translation kindly made for me by Mr. Douglas.

² Neumann (07); Zeiller (10).

³ Enock (07) p. 207.

certainty. The best specimen is shown in Pl. XIII, fig. 1: the branched axis is longitudinally striated and smooth; the pinnules are more or less deltoid, deeply dissected, and the ultimate segments are obtuse or truncate. A smaller piece of pinnule is reproduced in Pl. XIII, fig. 2. The broader piece of rachis seen in Pl. XIII, fig. 3, if found without any associated pinnules, might be mistaken for a portion of a *Cordaites* leaf.

Fig. 1 recalls *Sphenopteris furcata* Brongniart, an Upper Carboniferous species by some authors referred to *Diploptemna* or *Palmatopteris*; but in the Peruvian pinnules the segments are obtuse, and not acute as in *Sphenopteris furcata*. Comparison may also be made with *Eremopteris missouriensis* Lesquereux, as figured by D. White¹ from the Lower Coal Measures of Missouri, in which the ultimate segments are obtuse or truncate. Specific determination is probably impossible, and the occurrence of ferns or pteridosperms, in both Upper and Lower Carboniferous strata, with pinnules very similar to those shown in figs. 1 & 2, precludes any definite conclusion as to the question of geological age. Several Lower Carboniferous species have been figured, in which the pinnules bear a very close resemblance to the Peruvian specimens; the deeply-dissected form of the lamina suggests comparison with pinnules of species of *Rhodea* and *Sphenopteridium*.²

LEPIDODENDRON sp. (Pl. XIII, figs. 4-6.)

This specimen, part of which is shown in fig. 4, is an impression on a carbonaceous sandstone of a piece of a stem or branch 16.5 cm. long and 3 cm. wide, with several attached and indistinctly preserved leaves spreading over the rock at the edges. The fossil is doubtless part of a Lepidodendroid plant; the surface does not reveal at all clearly the form of the leaf-cushions, except at the lower end. An examination of the carbonized surface shows impressions of linear leaves pressed against the stem. Fig. 5 represents a single leaf-cushion, with a leaf-scar and the impression of part of a leaf. The specimen seen in fig. 6 shows more clearly the form of the leaves, each of which has a midrib.

These specimens unfortunately do not enable one to determine with any confidence the precise age of the plant-beds, as Lepidodendroid plants generally resembling that from Peru occur in both Upper and Lower Carboniferous strata.

SIGILLARIA sp., or LEPIDODENDRON sp. (Pl. XIII, figs. 7 & 8.)

The two specimens reproduced in figs. 7 & 8 are pieces of a stem having contiguous leaf-cushions which bear leaf-scars agreeing both with some types of Sigillaria, as, for example, *Sigillaria Brardi* Brongniart, and with certain species of *Lepidodendron*. On the upper part of several leaf-cushions there is a small circular scar,

¹ White (99) pl. v, figs. 1-3 a & pp. 6-19.

² See Nathorst (20) pl. i, figs. 11-13.

presumably a ligule-pit. No vascular-bundle scars or parichnos-scars can be detected. *Sigillaria Brardi*, although mainly a Northern Hemisphere Upper Carboniferous species, is recorded also from South Africa¹ and Brazil.² Some of the numerous specimens figured by E. Weiss as *Sigillaria mutans* Weiss³ closely resemble the small pieces shown in figs. 7 & 8. On the other hand, comparison may equally well be made with species of *Lepidodendron* from Lower as well as from Upper Carboniferous beds.

BOTHRODENDRON (?) sp. (Pl. XIII, fig. 9, and text-figure.)

Although it is by no means certain that the specimens shown in Pl. XIII, fig. 9 and in the text-figure belong to the same species, they may be considered together and regarded as possibly specifically identical, or at least very closely allied.

Bothrodendron (?) sp. (Natural size.)

The flattened piece of stem seen in fig. 9 is characterized by the spirally-disposed and widely-separated, slightly-prominent leaf-scars. Most of the surface is bereft of any carbonaceous film, and does not exhibit the original surface-features; but, on the right-hand side, a thin carbonaceous layer probably represents the actual surface, and on magnification the outlines of cells are clearly visible. The leaf-scars are prominent, transversely elongated, and rhomboidal. On the partly-decorticated surface there are discontinuous longitudinal ridges and an irregular transverse

wrinkling, but on the carbonized film no wrinkling is seen. There is no indication of any leaf-cushion, no ligular pit, and only a very faint suggestion in a few of the scars of a median vascular scar. The leaf-scars shown in the text-figure are rather more rounded, and appear as slightly concave areas (not projecting as in Pl. XIII, fig. 9).

In the small and widely-separated leaf-scars these fragments agree with *Bothrodendron*, *Pinakodendron*, and *Asolanus*. The form of the leaf-scar and the absence of a leaf-cushion are features more suggestive of *Bothrodendron*. The last-named genus extends from the Upper Devonian to the Upper Carboniferous.

¹ Seward (97) p. 326.

² White (08) p. 458.

³ Weiss (93) pp. 84 et seqq.

PLANTA INCERTÆ SEDIS. (Pl. XIII, fig. 10.)

On one piece of sandstone there are faint impressions of crowded branched filaments, some of which are shown in fig. 10. Their occurrence in a fairly-dense mass reminds us of the branched leaves of *Dicranophyllum Richiri* Renier¹ from the Coal Measures of Belgium; but they are more probably portions of pinnules of a fern-like plant, such as some of the Lower Carboniferous species referred to *Rhodea* or *Sphenopteridium*. Generic determination is hardly possible.

Conclusion.

Mr. Douglas, in his recent paper on 'Geological Sections through the Andes of Peru & Bolivia,' referred to the importance of obtaining accurate determinations of the plants which he collected from the Peruvian strata.² After a careful examination of the material, I submitted most of the specimens to Dr. Kidston,³ who kindly expressed his opinion thereon. My first impression led me to regard the Peruvian plants as Upper Carboniferous in age, and this conclusion, if correct, would raise a question of considerable interest, in view of the fact that no member of the *Glossopteris* flora is included in Mr. Douglas's collection. Dr. Kidston, however, is inclined to regard the palæobotanical evidence as more favourable to a Lower Carboniferous horizon. A re-examination of the specimens in the light of his suggestions caused me to modify my conclusions. The plants are too imperfect to serve as trustworthy guides: the rocks may belong to the upper part of the Carboniferous formation or, on the whole more probably, to the Lower Carboniferous. Lower Carboniferous plants similar to Northern Hemisphere types have previously been recorded from South America; but, so far as I am aware, no Upper Carboniferous flora is known from South America composed exclusively of Northern Hemisphere types, with no admixture of members of the *Glossopteris* flora. The inclusion of two Wealden species in the list given by Fuchs must be attributed to incorrect determinations; none of the specimens collected by Mr. Douglas can reasonably be referred to a Mesozoic flora. Further research is greatly to be desired, since the available data are inadequate as a basis for any positive statement.

My thanks are due to Mr. R. E. Holttum, of St. John's College, Cambridge, for assistance given to me in the preparation of this paper.

¹ Renier (10) pl. cxvii.

² Douglas (21) p. 250.

³ I am greatly indebted to my friend, Dr. Robert Kidston, F.R.S., for his helpful criticisms and suggestions.

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EXPLANATION OF PLATE XIII.

[The drawings, with the exception of that reproduced in fig. 5, were made by Mr. T. A. Brock.]

- Fig. 1. *Sphenopteris* sp. Branched axis and pinnule. Natural size.
2. *Sphenopteris* sp. Smaller pinnule. Natural size.
3. *Sphenopteris* sp. Piece of rachis, enlarged.
4. *Lepidodendron* sp. Natural size.
5. *Lepidodendron* sp. Leaf-cushion; slightly enlarged. *l* = impression of a leaf above the leaf-scar.
6. *Lepidodendron* sp. Natural size.
7. *Sigillaria* sp. or *Lepidodendron* sp. Natural size.
8. *Sigillaria* sp. or *Lepidodendron* sp. Natural size.
9. *Bothrodendron* sp. Leaf-scars as depressions. Natural size.
10. *Planta incertæ sedis*. Natural size.

DISCUSSION.

Mr. J. A. DOUGLAS, after expressing his gratitude to the Author for the trouble which he had taken in studying this collection, pointed out the possibility that the Wealden species recorded by Fuchs among Carboniferous forms were derived from the Cretaceous plant-bearing beds of the Island of San Lorenzo, and had become mixed with a collection from Paracas.

The speaker considered that the correct identification of these plants was of great importance, apart from clearing up the anomaly in Fuchs's list. David Forbes's statement that nowhere have we evidence of the existence of Carboniferous beds on the

whole coast of South America was now definitely shown to be incorrect.

This isolated Palæozoic fragment of Paracas must clearly be assigned to the coastal Cordillera, as distinct from the Mesozoic Western Cordillera, and its existence led to the hope that other fossiliferous Palæozoic rocks still awaited discovery among the crystalline rocks of the coast of Southern Peru. Further, the evidence afforded by these fossil plants seemed to support the view that the Andean Cordilleras, although subjected to repeated oscillation, had their origin at a very much earlier date than was generally recognized.

On stratigraphical grounds, it could be shown that an uplift took place during the interval between Mid-Devonian and Permo-Carboniferous times; and the surmise that the altitude of the chain thus formed fell little short of that attained by the existing range was suggested by the dissimilarity between the flora of the Pacific region and that of Gondwanaland on the east. At the present day the snowclad chain forms an effective barrier to plant-migration. Was it too much to suggest that similar conditions prevailed in late Palæozoic times? At any rate, it seemed to the speaker that the argument in favour of a land-barrier separating the two regions was more plausible than one in favour of a barrier formed by the sea.

T.A. BROCK DEL.

BOTHRODENDRON (?) , ETC.