Art. XV.—*Carboniferous Plants from Peru;*[1] by Edward W. Berry.

Just south of the port of Pisco the peninsula of Paracas, celebrated in the War of Independence, juts out into the Pacific, forming a bold wind-and-wave-swept headland (Lat. 13° 55′ S., Long. 76° 33′ W.). It is about 220 km. south of Callao and 25 km. southwest of the port of Pisco, and is of great geological interest since it is largely made up of continental Carboniferous sediments and constitutes one of the very few deposits of this character in South America, and the only known occurrence of rocks of this age on the West Coast of South Africa.

The outcrop of coal-bearing rocks on Paracas was discovered by F. C. Fuchs, who published a brief account[2] of it in 1900. Fuchs made a considerable collection of the fossil plants, which are now in the Museum at Lima, where I had the privilege of seeing them. He identified the following forms: *Calamites suckowii, Sphenopteris hartle benii, Lepidodendron sternbergii, Sigillaria tessellata, Stigmaria ficoides* and *Baiera pluripartita,* and considered the deposit to be of Upper Carboniferous age.

The true *Sphenopteris hartlebenii* of Dunker, which has since been referred to *Ruffordia goepperti,* is a characteristic species of the Wealden, and the Paracas form which Fuchs thought represented this species is *Palmatopteris furcata,* a rather widespread Carboniferous fernlike plant of the Sphenopterid group. Fuchs's *Baiera pluripartita* is not a Baiera but a species of the genus Eremopteris, his Sigillaria I was unable to identify from an inspection of the material, and as there are no true Sigillarias in my collections I cannot say whether his specific name is correct or not. His Lepidodendron is not *Lepidodendron sternbergii* but represents both of the species recorded from this locality in the present paper. His Calamites and Stigmaria appear to be correctly determined.

The scarcity of coal at tidewater on the West Coast aroused a great local interest in Fuchs's discovery, pertenencias were quickly taken out and much money was

[1] A fully illustrated account of this flora will be published at a later date. George Huntington Williams Publication, No. 9.

[2] Fuchs, F. C., Nota sobre el terreno carbonífero de la peninsula de Paracas, Bol. de Minas Industria y Construcciones, tomo 16, No. 7, Lima, 1900.

spent in putting down concrete-lined shafts and in diamond drilling, although the complete section is admirably exposed along the south shore of the peninsula. Prospecting has not resulted in economic development, since the coal seams are thin and the coal contains a prohibitive percentage of ash.

Subsequently Fuchs gave a brief account of the geology of this general region in his paper on the copper deposits around Ica and Nazca.[3] In this report he considers that the Carboniferous at Paracas is continuous to the eastward beneath the Pleistocene and recent deposits that form most of the surface of the country in the belt lying between the igneous rocks of the Western Range of the Andes and the present coast, i. e. the Pampa de Condor, Pampa de Chunchanga, Pampa de Pisco and Tablazo de Ica. Another account of the Paracas Carboniferous without, however, adding anything to our knowledge concerning it, was published by Dorca in 1909.[4]

Steinmann, who did not visit Paracas, saw Fuchs's collection at the Cuerpo de Ingenieros de Minas in Lima. In a short note published in 1910 he makes the interesting generalization that the plant-bearing Carboniferous in South America is Lower and the invertebrate-bearing Carboniferous is Upper in age.[5] He states, with his usual assurance, that the Paracas forms represent:

Archaeocalamites radiatus.
Lepidodendron cf. Veltheimi.
Lepidodendron cf. Volkmanni.
Sphenopteris affinis = S. furcata.
Rhodea filifera.
Rhabdocarpus.

None of these forms is represented in the large collections which I made at Paracas, nor did I see any of them in the Fuchs collection.

Finally in 1917 in Lisson's admirable compilation of Peruvian fossils[6] the two species *Lepidodendron rimosum* and *Lepidodendron obovatum* are listed from Paracas, the determinations being by the late Professor Zeiller,

[3] Fuchs, F. G., La Región Cuprífera de los Alrededores de Ica y Nazca; Cuerpo de Ingenieros de Minas, Bol. 29, Lima, 1905.

[4] Dorca, I. R., Estudio sobre los Yacimientos Carboniferos de Paracas, Bol. Soc. Ingenieros, vol. 11, pp. 104-130, Lima, 1909.

[5] Geol. Rundschau, Bd. 1, p. 50, 1910.

[6] Lisson, C. I., Edad de los Fósiles Peruanos y Distribución de sus Depósitos en Toda la Republica, pp. 20-21, Lima, 1917.

and the age is given as Westphalian. Both of these species are represented in my collections.

The question of the age of the Paracas deposits and their relation to the widespread Carboniferous limestones of the Andes is one of great importance. It was apparently some conversation with Señor Bravo, the Director of the Cuerpo de Ingenieros de Minas regarding the Paracas continental Carboniferous that was the basis for the beautiful diagrams of the relations of land and sea during Carboniferous time published by Bowman,[7] which he unfortunately located at Pacasmayo which is 805 km. north of Paracas in a region of crystalline rocks.

There was not time for a detailed study of the Carboniferous of Paracas during my visit, necessarily short since the peninsula is a practically uninhabited desert. The wide and desert coastal plain, interrupted only by the irrigated valley of Ica, that extends from the igneous foothills of the Western Range to the ocean, consists of wind-blown sands, desert pavement gravel, and paper shales. Similar deposits form the neck of the Paracas peninsula, which is thus the result of the block-faulted Carboniferous and apparently bears no relation to westerly spurs from the Andes or igneous intrusions in the Coastal Plain.

Following is a measured section of the easternmost fault block and was repeated in the next block to the southwest.[8] The horizons from which fossil plants were collected are indicated and there is no chronologic change in the flora from top to bottom although fossil plants are more varied in the lowermost horizon.

Thin to heavy bedded rather coarse greenish-gray sandstone,	13
Greenish-gray massive and crossbedded sandstone with varying amounts of shaly intercalations with Lepidodendron. (N. 21 E, 26 E)	75
Dark shale with sandstone layers less than a foot in thickness	55
Sandstone with a shale parting in the middle	35
Sandy and somewhat carbonaceous fossiliferous shale	80
Sandy shale (tunnel)	22
Massive sandstone passing into thin-bedded sandstone along the strike. (N. 9 E, 25 E)	30

[7] Bowman, I., The Andes of South America, p. 19.
[8] Measured by Professor Joseph T. Singewald, Jr.

Massive greenish-grey somewhat arkosic sandstone	15
Thin-bedded sandstone	10
Thin-bedded sandstone with dark shale (no coal) toward the top (tunnel in shale)	32
Alternating sandy and carbonaceous shale with 6 inch coal at top, abundantly fossiliferous (tunnel)	38
Massive greenish-gray somewhat arkosic sandstone	20
Shale carbonaceous above, sandy below (N. 20 E, 25 E) (tunnel)	10
Greenish-gray sandstone, thin-bedded above	5
Gray shale	2
Interbedded thin sandstones and shales	3
Shale	1
Gray arkosic sandstone	5
Sandy shale	18
Thin-bedded sandstone and sandy shale with more massive sandstone at base	70
Dark carbonaceous shale with 2 to 3 inches of coal at top, abundantly fossiliferous (N. 5 , 25 E) (tunnel)	18
Massive greenish sandstone	15
Sandy shale	13
Pleistocene	585

Section repeated by faulting to the southwest.

The materials are relatively coarse throughout and would seem to indicate rapid deposition. Between 53 and 54 per cent of the total thickness is described as sandstone, which is often coarse and arkosic. Of the 273 feet described as shale 192 feet are distinctly sandy, so that less than 14% of the total thickness, including the so-called coal seams, is fine-grained shale and even the coal contains much silty impurities. No underclays with rootlets, or upright stems were observed and the coaly layers have every appearance of having been formed of drift material, which also appears to have been the case in the probably contemporaneous and very similar continental Carboniferous examined on the Copocabanya Peninsula on Lake Titicaca in Bolivia.

The Flora.

The flora comprises the following forms:

Pteridophytes or Pteridospermophytes.

1 Palmatopteris furcata (Brongn.)
2 Eremopteris whitei Berry.
3 Eremopteris peruianus Berry.

Arthrophyta—Calamariales—Calamariaceae.

4 Calamites suckowii Brongn.
5 Calamostachys sp.

Lepidophyta—Lepidodendrales—Lepidodendraceae.

6 Lepidodendron rimosum Sternb.
7 Lepidodendron obovatum Sternb.
8 Lepidophyllum sp.
9 Lepidostrobus sp.
10 Stigmaria sp.
11 Knorria sp.

It is thus extremely limited, although some of the elements are exceedingly common, and this is especially true of *Palmatopteris furcata, Eremopteris whitei, Calamites suckowii* and *Lepidodendron rimosum.* I imagine that the coarseness of the sediments and the apparent drifting of the material is mainly responsible for the absence of a more representative flora. Thus the present collections contain no traces of Sigillaria, Cordaites, Sphenophyllum, calamite foliage, nor of any Neuropterids, Pecopterids, Alethopterids or Lonchopterids. It is this feature of the flora which is undoubtedly responsible for the opinon of Steinmann, quoted on a preceding page, that the Paracas flora is of Lower Carboniferous age.

A somewhat similar situation is furnished by the flora of the Kuttung series of New South Wales, where the so-called Rhacopteris flora appears to be wholly lacking in Neuropteris, Alethopteris and Pecopteris. Walkom, however, and quite rightly I believe, correlates this Kuttung flora with the Westphalian stage of the European section.

The nearest known occurrence of marine Carboniferous in Peru is at Huanta, Dept. of Ayacucho, 277 km. N.E. of Paracas. The only known outcrop of the marine Carboniferous west of the Western Range is at Cotahuasi, Dept. of Arequipa. This is about 150 km. inland from the present coast and about 395 km. S.E. of Paracas.

Continental Carboniferous, mostly of unknown age, is more widely distributed in South America than has been suspected. Thus there are some continental sediments in the lower part of the section on the Copacabanya peninsula, and Titicaca Island, at the Cerro de Lacctacucho, Sicuani, Dept. of Cuzco, at the Pongo Mainique on the Urubamba,

Dept. of Cuzco. Steinmann (Geol. Rundschau, Bd. 2, pp. 50-51, 1910) records Lepidodendron and *Rhacopteris inaequilatera* Göppert from near Huichaycota on the Rio Huallaga in the Eastern Range 1 km. south of Huánuco in the Department of that name. In the same publication similar deposits, said to contain *Archaeocalamites radiatus* and *Lepidodendron* cf. *Volkmanni* are recorded from Retamito, which is between San Juan and Mendoaz in the Argentine Cordillera.

I think that there can be no doubt that the Paracas Carboniferous is younger than the Dinantian stage of the European section and that it corresponds to the Westphalian stage. The marine Carboniferous of the Andes is usually considered to be of Uralian age, that is to say, Stephanian in terms of the continental section. Whether or not the marine series represents more than Uralian has not yet been definitely determined. The finding of one at least of the Paracas plants in the lower part of the section on the Copacabanya peninsula, Bolivia, several hundred feet below the fossiliferous limestones, would lead to the inference that the Paracas plant-bearing Carboniferous is older than the bulk of the marine Andean Carboniferous and especially the highly fossiliferous portion of the latter.

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