NOTE ON THE GEOLOGICAL AGE OF PHYÖNG-YANG COAL-FIELD.

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with Pl. XXII.

Up to the present the coal of the older age than the Jurassic has not been found in Japan except in Nagato and Bitchū, where a Triassic coal is known to occur as was confirmed by the discovery of plant fossils* in a shale accompanying it. In China, however, there exists a coal belonging to the Permo-carboniferous period as at Yentai and Pönn-hsi-fu in Manchuria. Therefore I have been paying a close attention during the past several years to the coal-fields of Korea, a country which, so to say, links the islands of Japan with the mainland of China.

My first research of the coal-fields of Korea which occupied more than two months was in the summer of 1912, when I gave a special attention to the neighbourhood of Phyöng-yang, where younger Palæozoic limestones are found interstratifying with coal-seams. In September of the same year, my friend Dr. I. Kikkawa of the Phyöng-yang Mining Office kindly sent me some plant-fossils which he had found in Sa-dong and Yong-tang, after carefully searching for them. These plants proved to be *Pecopteris cyathea* Schloth., *Pecopteris* sp., *Alethopteris* sp., *Tæniopteris multinervis* Weiss, *Sphenopteris* sp., *Aphlebia* sp., *Lepidodendron oculis-felis* Abb., *Lepidophyllum* sp., *Calamites* sp., *Annularia* nov. sp., *Sphenophyllum* nov. sp., *Cordaites principalis* Germ., and *Cordaites* sp.,† which are undoubt-

* M. Yokoyama, Mesozoic Plants from Nagato and Bitchū. (Journ. Sc. Coll. Japan, Vol. XX. Art. 5, 1905).

† S. Tokunaga, On the Geology of Phyöng-yang Coal-field in Korea. (Journal of Geography, Tōkyō Geogr. Soc., Vol. XXV., No. 289, 1913, in Japanese).

edly Palæozoic, the discovery of the plants of the same era being for the first time in the record of the Korean geology.

My second visit to Phyöng-yang was in the summer of the last year, two months having been then spent in making detailed investigations. The result was the discovery of several new fossil localities yielding abundant fossils fit for my further studies. The following is a preliminary account of the geology of the above coal-field.

The Phyöng-yang coal-field is some 30 miles from east to west, and about 8 miles from north to south, being bounded on the south by the river Tai-dong-gang and its branch, the Nam-gang. The railway station Syö-pho is situated at the northern extremity of the field, while the town Kam-dong is at its eastern and Kang-syö at its western limit. The first geologist who made the geological research of this coal-field was Mr. K. Nishiwada ; whereas it was Dr. T. Kochibe who called it Mesozoic in a map which he compiled together with Mr. E. Tamura. Dr. N. Fukuchi who studied the field in 1904 and 1905 proposed the name of “Phyöng-yang beds”, as it was not certain to him whether it is Mesozoic or Palæozoic. Dr. T. Iki in his report on the mineral resources of Korea, published in October 1906, enumerates four formations as developed in the coal-region, viz: the Quaternary, the Upper and Lower Mesozoic, the Younger Palæozoic (subdivided into two parts, the upper and the lower), and the Older Palæozoic, of which the upper part of the Younger Palæozoic is said to contain the coal-layers. In the geological map made by Messrs. H. Kawasaki and E. Tamura in March 1912, the same region is coloured as “Upper and Lower Daitō Series” which they took for Mesozoic. Recently Dr. T. Hiki also wrote a paper on the Phyöng-yang coal-field, but he did not touch the question of its age. From the above, it must be taken that the age of the coal-field of Phyöng-yang was still unsettled, and this was due to the fact that no fossils of value had not been hitherto discovered in the field.

But at present the discovery of many species of fossils by Dr. I. Kikkawa and myself in several places of the field enables me to advance an opinion on the age of the coal-field which seems to have been formerly so puzzling to many a geologist. It is my opinion that the coal-fields near Sa-dong, Ko-pang-san and Yong-tang which are now being mined range from the uppermost Carboniferous to the Permian. The field between the Peuk-gang and the Nam-gang is composed of the strata ranging from the Permian to the Triassic inclusive, with the exception of the lowest layer which may be contemporaneous with that of Sa-dong. The field near Kan-peuk-san situated in the north of the city of Phyöng-yang belongs to the Jurassic, except the part lying north of Syö-pho. A large part of the coal-field in the Mitsubishi concession occupying the western half of the Phyöng-yang field belongs also to the Jurassic, while a small area near Yong-in-dong is Palæozoic. The following are the reasons I arrived at these conclusions.

In the Sa-dong mine, on the third level in particular, many fossils were found in a slate, among which there was a trunk of a species of *Lepidodendron*, a fact which should be specially noted. Also leaves and a fruit of a *Lepidodendron* were discovered, but at present whether they all belong to the same species or not is not quite certain. Besides the above *Sigillaria*, and the trunks and leaves of *Calamites*, were found, also indicating that the layer is Palæozoic. The leaves of *Calamites*, resembling in their general outline to the Triassic *Annulariopsis inopinata* Zeiller, seem to belong to a new species, for which I am going to propose the name of *Annularia inaequifolia*. The occurrence of *Sphenophyllum* at Sa-dong is of a special importance, being represented by two species. The one is *Sphenophyllum emarginatum* Brong. var. *truncata* Schenk, obtained by Richthofen from the Carboniferous of the Kai-ping coal-field in China, but also found in the Carboniferous of Bohemia. The other is a new species, for which I intend to propose the name of *Spheno-*

phyllum macrophyllum. Moreover, the same coal-mine afforded six species of *Alethopteris* (including a new species which is going to be named *A. koraiensis* Tok.), two of *Pecopteris* (including *P. cyathea* Schloth.), two of *Neuropteris*, one of *Mariopteris* (*M. muricata* Schloth.), one of *Sphenopteris*, two of *Tæniopteris* (including, *T. multinervis* Weiss), two of *Næggerathia*, one of *Aphlebia*, one of *Cardiocarpum*, two of *Pterophyllum*, one of *Cycadites* and one of *Cordaite* (*C. principalis* Germ).

At Yong-tang, the slates afforded a considerable number of *Calamites*, *Sigillaria* and *Lepidodendron*, among which there is *Lepidodendron oculis-felis* Abb. also found by Zalesky and Yokoyama at Yentai. There are also two species of *Calamites* and one species of *Pecopteris* which latter occurs only at this locality. The forms common to Yong-tang and Sa-dong are *Annularia inaequifolia* Tok., *Sphenophyllum macrophyllum* Tok., *Pecopteris cyathea* Schloth. and *Cardiocarpum* sp. There can be no doubt, therefore, that Sa-dong and Yong-tang belong to the same geological system. *Lepidodendron oculis-felis* Abb. is known to occur in the Upper Carboniferous of Yentai and Shansi, while *Pecopteris cyathea* Schloth. is a species generally found in the uppermost Carboniferous, though it rarely occurs also in the Permian. *Mariopteris muricata* Schloth. is an Upper and Lower Carboniferous species in Europe. *Tæniopteris multinervis* Weiss which is Carboniferous in Europe, is also found in the coal-field of Pönn-hsi-fu, whereas *Cordaite principalis* Germ. ranges from the Lower Carboniferous up to the Permian. *Sphenophyllum emarginatum* Brong, var. *truncatum* Schenk is a species often found in the Carboniferous of China and Bohemia. From the above, it follows that the fossils found in the coal-field under consideration belong to a flora which is to a greater part Carboniferous and but also partly Permian.

At Chi-kot-dong in Ko-pang-san I found fossils also occurring at Sa-dong and Yong-tang, besides those which are peculiar to this

place. The rock in which these fossils are contained is not the hard black slate as found at Sa-dong and Yong-tang, but is a less hard sandy slate of a bluish or brownish colour. *Annularia inæquifolia* Tok. which I mentioned already as occurring at Sa-dong is very frequent at this place. Besides *Gigantopteris nicoticefolia* Schenk and *Callipteris heijōensis* Tok. (new species) are also very frequent. *Næggerathia kikkawai* Tok. (new species) is a species peculiar to this place, besides *Neuropteris*, *Tæniopteris* and *Thinnfeldia*. *Lepidodendron* and *Sigillaria* which are abundant at Sa-dong and Yong-tang are here almost wanting; but the occurrence of *Calamites* shows the Palæozoic character of the deposit. However *Callipteris*, *Thinnfeldia* and *Gigantopteris* which have been hitherto found in the Permian and the Triassic must be specially taken in consideration. *Gigantopteris nicoticefolia* Schenk was at first considered to be Upper Carboniferous when it was discovered by Richthofen at Lui-pa-kow in Yunnan. But afterward, Prof. Zeiller declared the Yunnan plants as belonging to the Triassic rather than to the Carboniferous. Dr. H. Yabe, too, after the study of his collection from Mun-gyong in Korea, expressed the same opinion in the Journal of the Science College, Imperial University of Tokyo. Most of the specimens I collected are much larger in size than those described by the above authors, and differ from them in certain respects. But there are also forms intermediate in size between the two. Therefore I deem it proper to take *Gigantopteris* as ranging from the Permian up to the Triassic.

I will now speak of the field lying between the Nam-gang and the Peuk-gang. Near Hoang-kyōng-dong in the south, several layers of coal are alternating with *Schwagerina* limestones. A similarly looking limestone is also met with in the north of our field. The rocks in the districts north of the above mentioned limestone series of Hoang-kyōng-dong strike from east to west and dip towards the north. In the southern part of the district representing the lower

part of the series, there occurs *Gigantopteris nicotiaefolia* **Schenk** together with *Nilssonia inouyei* **Yok.**, found some years ago in the Triassic of the province Nagato in Japan. Together with these Mesozoic fossils I happened to find out *Sphenophyllum speciosum* **Royle**. The genus *Sphenophyllum* is mostly peculiar to the Palæozoic, but the above-named species was described by Feistmantel from the lowest Triassic of India. Therefore the district under consideration must belong somewhere to a period between the Permian and Triassic.

The environs of Yong-dong in the Mitsubishi mining district which is situated on the west of Phyöng-yang are Palæozoic. Here I found *Calamites*, *Næggerathia* and *Alethopteris* *sp.* besides *Alethopteris koraiensis* **Tok.** which occurs also at Sa-dong. Therefore this Yong-dong district probably belongs to the same age as Sa-dong. In other places of the same district, we find many Jurassic fossils among which I may mention *Hildoceras inouyei* **Yok.**, an important Liassic form. Among plant fossils, I was able to detect *Todites williamsoni* **Brog.**, *Podozamites lanceolatus* **L. H.**, *Pinus nordenskjöldi* **Hr.**, *Asplenium rösserti* **Presl.**, *Phönicopsis*, *Nilssonia*, *Ginkgo*, *Ginkgodium* and others.

From the above, I arrive at the following conclusions :—

- (1) The Phyöng-yang coal-field belongs to the geological periods ranging from the Uppermost Carboniferous to the Jurassic, just as those of Shantung and other provinces of China.
- (2) Some workable coals in the Phyöng-yang field, are alternating with Palæozoic limestones.
- (3) The fossils of the Youngest Palæozoic are found together with those of the Oldest Mesozoic in one and the same layer.

Thus the region is the one which is of a great geological interest, and I hope I may be able in future to report on it in a greater detail. The accompanying geological map is largely based on that previously published by my colleagues Mrs. H. Kawasaki and E. Tamura, though some changes were found necessary in its execution.

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