Hao-kang Coal Field, Sankiang Province Manchuria

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I. Locality, Transportation and Topography

The Hao-kang coal field is located in Hao-li Hsien, Sankiang Province, with Hsing-shan village as the center, and extends for some 120 km NNE–SSW from Lo-pei near the boundary between the Soviet Union and Manchuria on the north to the Sung-hua Chiang, or the Sungari River, passing through the plains west of the town of Hao-li-kang on the south.

The description here is limited to an area 30 km long and 4.5 km wide where the coal seams are actually recognized due to military operations in the northern part of the coal field during my investigation in 1940, and because a heavy mantle of surface sediments in the southern section was so thick that it could not be geologically determined at all.

The maximum width of the coal-bearing beds is known to be some 4.5 km in the vicinity of Hsing-shan village. The Hsing-shan head office of the Hao-kang coal mine is located at long. 130°18′E and lat. 47°20′N.

A small railway is operated for transporting coal and other materials some 56 km between the Lien-chian-kou railway station of the Chia-mu-ssu—Sui-hua railway line and Hsing-shan, the main coal mine.

Lien-shan-chieng station is located on the northern bank of the Sungari River, just opposite the city of Chia-mu-ssu. The station is not only a land transportation center but is also useful in summer as a navigation harbor on the Sungari River, especially for the city of Harbin in the upper reaches, although all transportation facilities are closed the other half of the year except for some travel by sledge.

The west side of the coal field is bounded by several fairly high hills which extend from NE to SW, while the east side of the coal field is surrounded by a vast area of swamps along the Amur and Sungari rivers except for a few small hills as islets.

There are several streamlets in the coal field, such as the Wu-tun Ho, Shih-tou Ho, Hao-li Ho, and the A-ling-ta Ho all originating generally from hills to the northwest and running SE or S to empty into the Sungari River. These streamlets

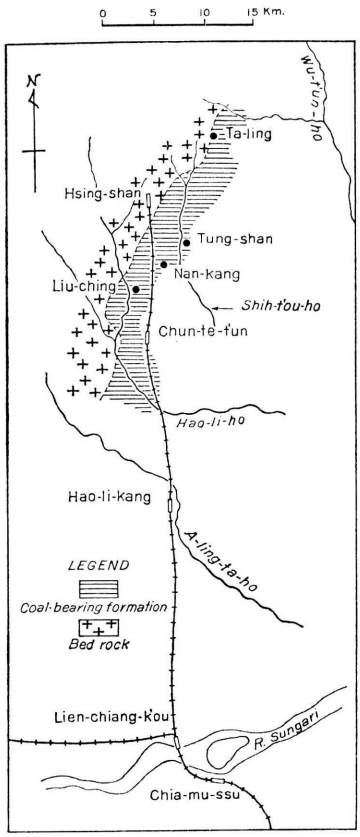

Fig. 1. Map showing position of the Hao-kang coal field.

usually meander remarkably in the alluvial sediments of the district. Almost all alluvial plains along these streamlets are often completely covered by water during floods in the summer, and sometimes form enornous swamplands.

II. Geology

Owing to the thick cover of surface sediments in one part of the coal field, the general geology of the district is not clear yet though some natural exposures of the series above the coal-bearing strata exist.

The principal formations of the coal-bearing strata can be seen only in open-pits, or along clearings for roads and railroads, or by prospecting boring; there were several investigations on this subject before my studies in 1939 and 1940.

The geology of the coal field is divided as follows, in descending order:

A. Alluvial sediments
B. Nan-kang conglomerate formation
C. Hsun-te pyroclastic formation

D. Hao-kang series
E. Granite and gneiss
F. Limestone

A. Alluvial Sediments

The alluvial sediments are distributed mainly in the flood plains along each streamlet mentioned above. They are mostly arkose sand and gravel derived from granite. Some thin clay beds are sometimes interbedded in these sediments. The surface of the sediments is usually covered with black earth (chernozem). The thickness of the alluvial sediments increases more to the south of the coal field than to the north, *viz.*, it is estimated at 10 m near Hsing-shan village, 80 m in the swampland west of Hsun-te-tun, and over 100 m south of the town of Hao-li-kang.

A fossil mammal, *Elephas mammonteus*, was found in a sand bed 7 m beneath the ground surface along the eastern wall of an open-pit of No. 2 coal seam.

B. Nan-kang Conglomerate Formation

The Nan-kang conglomerate formation covers the upper and middle coal-bearing strata of the Hao-kang series. It forms hills somewhat higher than the neighboring ground. A quarry at Nan-kang, south of Hsing-shan, is the type locality of the conglomerate, where it is excavated for ballast. The general thickness of the formation is about 100 m here.

The formation strikes generally N–S and dips about 5°E. It consists principally of conglomerate interbedded with lenticular sandstone.

The pebbles constituting the conglomerate are variable in size, usually smaller than a human skull. They are mainly liparite, sandstone, granite, porphyrite and quartz, of which the first predominates occupying more than 50% of the constituents. All of the pebbles are remarkably rounded due to erosion and corrosion.

The direct relation between the conglomerate formation and the underlying Hsun-te pyroclastic formation is not clear. However, it can be assumed that the conglomerate formation may lie with a clinounconformity on the pyroclastic formation, because of the difference in dip of the two series; the former dips only 5° to the east, while the latter dips 20° in the same direction, although the strike of both series is similar at the same locality.

C. Hsun-te Pyroclastic Formation

This formation directly covers the Hao-kang series and tells us the period of volcanic activities in the Hao-kang region. All sediments of the Hsun-te pyroclastic formation are nothing but the results of activities of volcanoes in this region; a fact which is proved by the abundant volcanic ejecta in most of the formation.

The formation can be divided into two members, sandstone in the upper part and andesite in the lower part.

The sandstone member, over 500 m thick, crops out in the northeast of Hsun-te-tun. It consists chiefly of coarse-grained yellowish brown sandstone, accompa-

nied by conglomerate and sandy conglomerate, and is intercalated with a thin coal seam several centimeters thick. The upper limit of this member remains unknown on account of the heavy mantle of sediments.

The andesite member is distributed at a small hill south of Ta-ling and in the northeast of Hsun-te-tun. It consists of gray or grayish black andesite, andesitic agglomerate, tuff, tuffaceous conglomerate, black shale, grayish white sandstone, grayish yellow conglomeratic sandstone and shale; the tuffaceous conglomerate generally contains fist-size gravel of quartz and granite, sometimes with boulders of granite. White liparite tuff occurs in the upper portion of the member. The black shale yields fossil plants, such as *Brachyphyllum* sp., and bivalves. The gray andesite usually contains black hornblende as phenocrysts in the hard and compact groundmass.

The direct relation between the Hao-Kang series and the Hsun-te pyroclastic formation could not be observed. There may exist an unconformity between the two but the structural discrepancy is negligible.

The geologic age of this formation may be Upper Jurassic or Lower Cretaceous, because the age of the underlying Hao-kang series is at least Upper Jurassic as indicated by some index fossils and is evidently correlated with formations of northeastern and central Manchuria.

D. Hao-kang Series

The name Hao-kang series is used for the Jurassic formations of northern Manchuria. The Hao-kang coal field is the type locality of this series. It is thought to be a series of formations which have accumulated continuously without any interruption.

The series can be divided into three coal-bearing formations, the upper, the middle, and the lower. Sandstone commonly predominates, but the lower and the upper formations are locally intercalated with conglomerate.

Productive coal seams occur mostly in the middle formation; only one coal seam is workable in the lower formation though there are several thin coal seams; no minable seams were found in the upper formation at the time of the investigation.

The abundance of fossil plants corresponds to the productivity of coal seams, that is, the abundance of fossils coincides with the richness of coal seams, as in the middle formation, and the scarcity of fossils indicates fewer and less workable coal seams, as in the upper and lower formations.

The upper formation is separated from the middle formation by the top of No. 1 coal seem of the middle formation, which, in turn, is separated from the lower formation by the white sandstone which lies between No. 5 and No. 6 coal seams. The upper formation is generally yellowish gray to yellowish brown, while the middle formation is predominantly grayish white. The sandstones near the coal seams are remarkably white.

Upper coal-bearing formation:—Only a part of this formation was investigated by means of boring, owing mainly to poor exposures and to the lack of any productive

coal seams in it. The formation is composed mostly of coarse-grained sandstone and conglomeratic sandstone, with a total thickness about 500 m. A small exposure of the upper part of this formation along the Shih-tou Ho exhibits some impressions of fossil plants in the yellowish gray conglomeratic sandstone. The boring cores revealed that the middle and lower parts of this formation are composed of grayish yellow sandstone, conglomerate, conglomeratic sandstone and shale, with a thin lenticular coal seam.

Middle coal-bearing formation:—There are ten coal seams in the Hao-kang coal field, and five of them, No. 1 to No. 5, occur in the middle coal-bearing formation. No. 2 through No. 5 are thick and workable. The formation consists chiefly of yellowish gray or grayish white sandstone, interbedded with white arkose sandstone or white tuff. Plant fossils are abundant in the horizons above and below the productive coal seams.

No. 1 coal seam:—Its properties are only partially known as a result of some prospecting borings, and coal production has not yet begun at this coal seam.

No. 2 coal seam:—The succession of beds observed in the open pit is as follows in descending order: Dark grayish shale; yellow coarse-grained sandstone; alternation of yellow sandstone and gray sandstone; a thin coal seam; gray shale; a thin coal seam; yellow sandstone; No. 2 coal seam.

The following plant fossils are found in the gray shale:

Coniopteris hymenophylloides (BRONGN)
Onychiopsis elongata (GEYLER)
Sphenopteris suessi (KRASSER)
Sph. sp.

Of these, *Onychiopsis* and *Sphenopteris* are especially abundant. *Podozamites lanceolatus* (L. et H.) is found to aggregate at about 10 m above this horizon.

No. 3 coal seam:—The following plant fossils are found in sandstone and shale above No. 3 coal seam and in a parting of the coal seam as observed in the open pit:

Cladophlebis denticulata var. *tuberculata* THOMAS
Cl. lobifolia (PHILLIPS)
Sphenopteris suessi (KRASSER)
Taniopteris sp.
Baiera gracilis BUNBURY et BEAN (MS)
Eladocladus manchurica (YOKOYAMA)
Pityophyllum lindstroemi NATH.
Podozamites sp.
Carpolithus sp.

No. 4 coal seam:—No fossil has been reported from this coal seam yet. The thickness of the coal seam is over 7 m with a parting of sandy shale, about 0.2 m thick, in the middle. The hanging wall is yellow sandstone, but the footwall is not known.

No. 5 coal seam:—White arkose sandstone forms the hanging wall and the foot-

wall of the coal seam. The following plant fossils are found in the hanging wall:

Equisetites sp.
Cladophlebis denticulata (BRONGN.)
Cl. lobifolia (PHILLIPS)
Cl. nebbensis
Coniopteris cfr. *hymenophylloides*
Co. sp.
Sphenopteris suessi (KRASSER)
Sph. sp.
Nilssonia sinensis YABE et OISHI
Nil.? sp.
Ginkgoites sibirica (HEER)
G. digitata (BRONGN.)
Baiera manchurica YABE et OISHI
Czekanowskia rigida HEER
Phoenicopsis sp.
Stenorachis sp.
Elatocladus manchurica (YOKOYAMA)
El. submanchurica YABE et OISHI
El. sp.
Elatides sp.
Pityophyllum longifolium (NATH.)
Pityostrobus Endo-riujii OISHI
Podozamites lanceolatus (L. et H.)

Lower coal-bearing formation:—The formation is composed mainly of yellow to grayish brown arkose sandstone and gray conglomerate, the latter contains pebbles of quartz porphyry or liparite, 2 to 10 cm in diameter. Conglomerate predominates in the north of Hsing-shan, while sandstone is the leading rock in the south, and no basal conglomerate is found in the vicinity of Hsing-shan. The exact boundary between the formation and the basement (probably granite) is hardly determined on account of the thick surface soil, so that prospecting by means of drilling is necessary. Even by trenching, it is difficult to discriminate the weathered zone of the granite from the weathered basal sandstone of the lower coal-bearing formation. It is probable that the relation between this formation and the basement is locally unconformable and locally in fault-contact.

No. 6 coal seam:—This is the thickest coal seam in the Hao-kang coal field. It is over 20 m thick near Hsing-shan and 13.5 m in the Liu-ching district to the south. The following plant fossils are found in the pit at Tou-tao-kou:

Equisetites sp.
Cladophlebis denticulata (BRONGN.)
Otozamites sp.
Czekanowskia rigida HEER
Pityophyllum longifolium (NATH.)

Podozamites lanceolatus (L. et H.)
Pinites sp.

There are four more coal seams, Nos. 7, 8, 9 and 10, beneath No. 6, but in the Hao-kang coal field they are too thin to be worked. The coal seams are intercalated with yellow arkose sandstone and conglomerate. *Equisetites* sp., *Cladophlebis* cf. *lobifolia* (PHILLIPS), *Phoenicopsis* sp. and other plant fossils have been collected at the prospecting site of No. 8 coal seam at Tou-tao-kou.

The geologic age of the Hao-kang series should be Upper Jurassic, corresponding to the coal-bearing beds of the Mi-shan coal field in northeastern Manchuria and those of the Fu-hsin coal field in southwestern Manchuria, on the basis of the *Onichiopsis-Sphenopteris* flora which is common among the three coal fields.

E. GRANITE AND GNEISS

Granite and gneiss are distributed in the western hills of the Hao-kang coal field. Their boundary with the coal-bearing beds is easily defined in the north because of the characteristic topography, but in the southern area the boundary is inferred only by boring, since the granite and gneiss are distributed even beneath the swamps along the Hao-li Ho, as observed at Hsun-te-tun.

The gneiss is coarse-grained granite-gneiss and crops out at the Shih-hui-yao quarry. It sometimes contains impure limestone as xenoliths which have been contact-metamorphosed into marble. The gneiss is also accompanied by quartz diorite. All these rocks with granite make up the basement of the coal-bearing formations in the Hao-kang district.

F. LIMESTONE

Limestone crops out at a point 1.5 km NNW of the Hao-kang coal mine office in an extremely small area, occurring mostly as small masses enclosed in the granite and the gneiss by which it was metamorphosed into saccharoidal white crystalline limestone (marble). Under the microscope the limestone is found to consist chiefly of white crystals of calcite, less than 1 cm in diameter.

III. Geologic Structure

The general strike of the Hao-kang series and the Hsun-te pyroclastic formation is N20°E, dipping some 20° to the southeast, showing a monoclinal structure. The overlying Nan-kang conglomerate formation dips easterly at an angle of some 5°, much gentler in dip than is the underlying series. The relation between these two seems to be clino-unconformable.

There are two groups of faults in the Hao-kang coal field; one is the strike-fault and the other is the dip-fault. The former is rather rare, but is exemplified by the Shih-tou-ho fault that runs roughly N–S along the Shih-tou Ho and cuts the coal-bearing beds. On account of this fault, the principal coal seams make their appearance repeatedly near Tung-shan in the east.

By the group of dip-faults the Hao-kang coal field can be divided into the following five sections:

Ta-ling Section:—It comprises the area north of the Ta-ling fault which extends NW from Liu-tao-kou in the upper reaches of the Shih-tou Ho. The northern limit of this area remains unknown.

Hsing-shan Section:—This is an area trending E–W some 8 km between the Nan-kang fault, which runs E–W through the railroad cut at Nan-kang, and the Ta-ling fault. This section comprises four coal mines; Ta-ling, Hsing-shan, Tung-shan, and Nan-kang.

Liu-ching Section:—This is an area between the Nan-kang fault and the so-called No. 6 fault which runs E–W in the vicinity of No. 6 signal station on the railroad. The E–W length of this area is at least 5.5 km. The Liu-ching coal mine is located in this section.

Hsun-te Section:—The area of this section is 6.5 km E–W and lies between No. 6 fault and the Hao-li-ho fault of E–W trend passing through Hsun-te station. Existence of coal-bearing beds has been confirmed by boring, but exploitation is not started as yet, on account of the thick surface soil.

Hao-li Section:—The section comprises an unsurveyed area south of the Hao-li-ho fault. However, existence of at least one coal seam, some 5 m thick, has been confirmed in the river bed of the Hao-li Ho, west of Hsun-te-tun.

IV. Coal Seams, Reserves and Properties

The mode of occurrence of coal in the Hao-kang coal field is described below, mainly on the basis of investigations by Uchino and Bessho (1935) of the Geological Institute, South Manchuria Railway Company. The materials are those from the Hsing-shan, Tung-shan and Ta-ling areas, excluding those of the area south of Nan-kang where detailed prospecting has been done later.

The thickness of each coal seam at the Hsing-shan and Tung-shan coal mines is as follows:

Coal seam	Thickness (m)
East No. 1	13.3
East No. 2	7.9
East No. 3	5.4
No. 2	5.8
Coal seam below No. 2	3.2
No. 3	7.7
No. 4	4.1
No. 5	5.6
No. 6	13.5
No. 7	3.7
No. 8	3.6
No. 9	2.6

Coal seams No. 2 to No. 6 are being worked at the Hsing-shan coal mine. No. 7 to No. 10 are not productive. Seams East Nos. 1, 2 and 3 are those at the Tung-shan coal mine, and probably correspond to Nos. 2, 3 and 4 coal seams of the Hsing-shan coal mine due to the Shih-tou-ho fault, that is, No. 2 of Hsing-shan corresponds to East No. 1, and No. 3 corresponds to East No. 2, and so on.

The mode of occurrence of the coal seams of the Nan-kang coal mine is quite similar to that of the Tung-shan coal mine. At the Liu-ching coal mine No. 6 coal seam is as thick as 13.5 m and other seams cannot be thinner than those in the Hsing-shan area. If my memory serves me right, the apparent thickness of some coal seams determined by test boring in the Hsun-te area was 11 m for No. 5 coal seam, 4 m for No. 4 and 8 m for No. 3. In the Hao-li area only one coal seam, about 5 m thick, is known.

In 1935 UCHINO and BESSHO estimated the reserves of coal in the Hsing-shan, Tung-shan and Ta-ling areas at 644 million tons. The reserves were calculated again in 1944 by the Committee of Investigation of Coal Reserves in Manchuria. In the calculation the Hsun-te and Liu-ching areas were included, and the total amount, including ascertained, inferred and expected reserves, was estimated at 1,700 million tons.

Representative coals of the Hao-kang coal field were analyzed by the Central Laboratory of the South Manchuria Railway Company, with the result as follows:

Coal seam	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)	Sulphur (%)	Coking power	Calorie
South No. 2	2.13	10.84	33.76	53.36	0.44	Coking	7,120
North No. 2	1.94	3.25	39.28	52.53	0.23	〃	7,600
No. 3	2.24	8.03	34.72	55.01	0.21	〃	7,370
No. 4	1.58	34.26	25.72	38.44	0.23	〃	5,090
No. 5 (lower)	1.62	7.70	38.98	51.70	0.24	〃	7,510
No. 6 (upper)	1.42	7.77	34.49	56.23	1.02	〃	7,530

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