GEOLOGIC COLUMN AND UNIT DESCRIPTION

AGE	ROCK UNIT	LITHOLOGY; THICKNESS WHERE KNOWN	UNIT DESCRIPTION
QUATERNARY – Recent	Alluvium	Silt, sand, gravel and clay; thickness less than 20 meters	Recent deposits covering relics of low terraces and flood plains consist of silt, sand, gravel and clay of fluviatile origin. The thickness is generally 5 to 10 m, but in broad flood plains it locally attains a maximum of 20 m. The broad flood plains along the Wo-k'en Ho [臥 蚊 河] and the lower reaches of the Ma-leng Ho remain almost intact, having no development of gullies, and appear as if they are of the latest deposition in the process of subsidence.
QUATERNARY – Pleistocene	Diluvium	Silt, sand, gravel and clay; thickness less than 50 m	The Diluvium consists of unconsolidated fluviatile and fluvio-lacustrine deposits of silt, sand, gravel and clay, in association with some detritus. Because of lack of fossil evidence it is hardly distinguishable from the Alluvium and the Neogene. [Compiler's note:- A soft sedimentary deposit distributed on the hills west of Tang-pi-chen [當 壁 鎮] on the Manchuria-USSR border is assigned to the Diluvium on this map, but has been revised to the Neogene by D. V. NALIVKIN (1955) in the Geological map of USSR.] The Diluvium on the hills extending from Po-li [勃 利] as far northwest as Erh-tao-ho-k'ou [二 道 河 口] is predominantly gravel, but in other areas the Diluvium seems to consist of fine sand and a small amount of pebbles. The total thickness of the Diluvium may be about 50 m.
	UNCONFORMITY		
TERTIARY	Neogene basalt	Olivine-pyroxene basalt and doleritic titaniferous augite-olivine basalt; maximum thickness more than 300 m	The Neogene basalt occurs as lava plateaus and lava flows. The basalt that constitutes the plateau region comprising P'ing-yang-chen [平 陽 鎮], Huang-ni-ho-tzu Ho [黃泥河子河], Ta-shih-t'ou Ho [大 石 頭 河], Liu-mao [柳 毛] Colony, and Li-shu-chen [梨 樹 鎮] may locally attain a maximum thickness of more than 300 meters. The border zone of the region is dissected into lava-capped mesas and buttes. The basalt is chiefly olivine-pyroxene basalt with a relatively uniform mineral composition, dark gray, poor in megascopic phenocrysts, and somewhat vitreous; in places the basalt is intercalated with, or underlain by, unconsolidated tuffaceous sand and gravel. A number of terrace-like exposures of doleritic titaniferous augite-olivine basalt are distributed in the basin of the Hsiao-mu-leng Ho [小 穆 稜 河], on the hills north of Yung-an-t'un [永 安 屯], and on the low terraces east of the Pan-chieh Ho [半 截 河]. Exposures of a notably exfoliating basalt are also found in the upper reaches of the Nao-li Ho [鬧 力 河] and the Fei-te-li Ho [特 德 里 河]. All these exposures are Neogene lava flows which were dissected into detached blocks. The thickness of these lava flows is not known.
	UNCONFORMITY		
	Undifferentiated Mesozoic beds	Includes Mishan series, andesitic flows, Huashan series and Sungari series; thickness not known	Undifferentiated Mesozoic beds occupy a broad area south of the Wo-k'en Ho, and consist of various rocks probably including the coal-bearing Mishan series, flows of andesitic rocks, the Lower Cretaceous Huashan series and the Middle to Upper Cretaceous Sungari series. Similar beds lie beneath the Diluvium which covers the hills north of the Wo-k'en Ho, although no detailed survey was made there.
MESOZOIC – Upper Jurassic - Lower Cretaceous	Huashan series or Lower Cretaceous formation	Tuffaceous sandstone and tuff, andesitic tuff and breccia; thickness 400 to 600 m	The Huashan series, or the Lower Cretaceous formation, is generally 400 to 600 meters thick, consisting in descending order of interstratified sandstone and shale, and an assemblage of andesite tuff and breccia which occasionally grades into the basal conglomerate. No coal seam of any economic value is found in the Hua-shan series. The series covers the Mishan series with a slight unconformity or disconformity.
	Andesite	Augite andesite, dacite, plagioclase liparite and volcanic breccia; thickness several hundred meters	Andesite is mainly augite andesite, accompanied by dacite and plagioclase liparite, and locally associated with volcanic breccia. The andesite flows and sheets south of Po-li may be several hundred meters thick, and may be contemporaneous with the basal conglomerate of the Huashan series.
	DISCONFORMITY		
	Mishan series or Upper Jurassic formation	Sandstone, shale, conglomerate, bentonite and coal; total thickness less than 2,500 m	The Mishan series, or the Upper Jurassic formation, is a terrestrial formation which can be roughly divided into the coal-bearing Maleng and Mishan formations in descending order. The Maleng formation is generally tuffaceous and is 100 to 700 m thick. The Mishan formation is generally marked with arkosic sediments; its exposures in the drainage basin of the Ma-leng Ho range from 180 m to 1,500 m in thickness, and in the Po-li coal field the thickness is reported to attain 2,400 m. The stratigraphic relationship between these two coal-bearing formations is nearly conformable. Nevertheless, the Maleng formation is not necessarily accompanied by the underlying Mishan formation, as for instance, in the vicinity of Li-shu-chen and in the eastern part of the Pai-ts'ao Kou [百 草 溝] drainage basin where the Maleng formation rests directly upon the pre-Jurassic bedrocks. Coal of the Maleng formation is low to medium grade bituminous and is noncoking, while coal of the Mishan formation is medium to high grade bituminous and strongly coking. The so-called Mishan coal is one of the most important coke resources for the iron and steel industries of North Korea and Manchuria. (Refer to Table I.) Recurrence of synclines and anticlines, with their axes trending generally east or east-northeast, is a prevailing structure of the Mishan series in the map area. The fossil flora of the Mishan series is similar to the Petori and Ryōseki floras of Japan and also to the Naktong flora of Korea. (Refer to Table II.) According to S. NAGAO the flora belongs to the "Cnychiopsis series" named by S. ŌISHI, and is closely related to the "Nikan flora" of Siberia. Many of the floral species are common between the Maleng coal-bearing formation and the Mishan coal-bearing formation. In the Maleng formation the occurrence of Brachyphyllum and Sphenolepidium is especially noteworthy, because they are known as index fossils of the Wealden (Lower Cretaceous) epoch in various places of the world. Sphenolepidium sternbergianum Dkr. is characteristic of the Maleng coal-bearing formation. The Maleng coal-bearing formation is also marked with a great number of individuals of Coniferales fossils, especially Elatocladus and Sphenolepidium, which suggests that the flora may be a predecessor of the so-called Ta-la-tzu flora which is predominated by arid inland-type Coniferales of the Wealden epoch. Estheria sp. was also reported from the Mishan series of the Po-li district.
	UNCONFORMITY		
PALAEOZOIC – Carboniferous - Permian	Pre-Jurassic granite	Biotite granite and hornblende-biotite granite	The pre-Jurassic granite is chiefly biotite granite and hornblende-biotite granite, and has contact-metamorphosed older rocks. Dikes of felsite and lithoidite occurs in the marginal parts. In the Hei-pei [黑 背] district, a few diorite zasses are found in association with granite.
	INTRUSIVE CONTACT		
	Upper Paleozoic or Touman formation	Slate, hornfels, phyllite, limestone and quartz schist; thickness not known	The Upper Paleozoic, or the Touman formation, consists of an aggregation of slate, hornfels, phyllite, limestone, and quartz schist. The total thickness is not known. No fossils have been reported as yet. Lithologically the formation resembles the Touman formation of Chien-tao Province which represents the Permo-Carboniferous marine formation in northeastern Manchuria.
PALAEOZOIC – Devonian	Lower Paleozoic or Heitai formation	Green tuff, shale, sandstone and conglomeratic arkose; thickness not known	The Lower Paleozoic, or Devonian, formation is known by the name of Heitai formation in the Hei-t'ai [黑 台] district. It consists, in descending order, of green tuff, interstratified black shale and sandstone, coarse sandstone, conglomeratic arkose and calcareous sandstone (20 to 30 m thick) which grades into limestone in places. Fossils collected from the limestone by G. MORIZA and others were identified by H. YABE and T. SUGIYAMA as follows: Brachiopoda Flectospirifer grabaui YABE and SUGIYAMA Spirifer sp. indet. Atrypa aspera (WILCKENS) Coral Favosites multispinulosus (YABE and SUGIYAMA Bryozoa Lioclema (Lioclemella?) sp. Trilobita Proetus-like form, gen. sp. indet. The Heitai formation was named by SUGIYAMA and was correlated with the Middle Devonian by M. NODA. The thickness of the formation is not known.
	UNCONFORMITY		
PRECAMBRIAN (?)	Gneiss or Mashan series	Granite gneiss, mica schist, sillimanite granulite, dolomite and limestone; thickness not known	The gneiss, or the Mashan series, is a metamorphic complex consisting of granite gneiss, mica schist, sillimanite granulite, dolomite and limestone. According to S. NAGAO the complex was intruded by granitic magma in three different ages, the youngest of which is the afore-mentioned granite (g2). The gneiss constitutes the bedrock of the Mishan series. The name Mashan series was provisionally given by G. ASANO to the metamorphic complex near the coal field of Ma-shan [馬 山]; its age has not been determined although its lithology closely resembles the Precambrian schist of South Manchuria.

(Column not drawn to scale)

ECONOMIC VALUE

(Au) The Hei-pei placer gold mine (long. 130° 05' E, lat. 45° 05' N) was opened about two hundred years ago, and was intermittently worked by governmental and semi-governmental organizations. Placer gold occurs in the Recent fluviatile deposits and the Pleistocene detrital and terrace deposits. The thickness of the auriferous beds may attain 10 meters, although natives worked only to the depth of 2 to 3 meters. The old workings extend for 25 kilometers with a width of 100 to 300 meters.

⊗1 Ma-leng coal mine. This mine, located in the vicinity of Pa-chia-tzu [八 家 子], was opened in 1924 by a Russo-Chinese corporation. Later in 1932, the corporation was placed under the administration of the Chinese government, then reorganized in 1937 as the Ma-leng Coal Mining Company. In the mine area are found two or three workable seams of coal, 0.7 to 2.5 m thick. The coal is slightly coking or noncoking, and the analysis reveals the following properties: H_2O 2.33%, ash 21.41%, volatile matter 30.07%, sulphur 0.27%, fixed carbon 46.12%, and calorific value 6,200 cal/kg. Most of the coal is consumed in Harbin for industrial and domestic heating purposes. As of 1940 the probable reserves were estimated at 14,000,000 tons, including 5,000,000 tons of workable amount.

⊗2-5 Mi-shan coal mines. The main office is at Chi-ning-chieh [鷄 寧 街]. First the Chi-hsi mine was opened in 1911 by a Chinese and was intermittently operated until 1940 when the Mi-shan Coal Mining Company was founded by the Manchurian government. The company set up district mining offices at Ti-tao [德 道], Heng-shan and Chi-hsi [鷄 西], Cheng-tzu-ho [鄭 子 河] and Ma-shan [馬 山]. At that time the Chining - Siachengtze railway and the Linkow - Hulin railway were laid, and the company made every effort to cooperate with the Manchoukuo government for the five-year plans. The Ti-tao area has 40 coal seams; 15 of these are 0.7 to 2 m thick and 7 were worked. The Cheng-tzu-ho area also has 40 seams, of which 17 are more than 0.7 m in thickness and 2 were worked. The Heng-shan area has 6 workable seams, each about 2 m thick, but the total number of seams is not known. The Chi-hsi area has 7 seams, of which 2 were workable, being 1.9 m and 1.7 m thick. The Ma-shan area has 3 seams with respective thicknesses of 2, 1, and 2 m; 2 of them were worked. The Mishan coal is generally highly coking and can be used in the manufacture of blast-furnace coke. Average analytical values are as follows:

Locality	Kind	Percent					Calorific value	Analyst
		H_2O	Ash	Volatile matter	Carbon	S		
Ti-tao	Unscreened	1.10	18.69	21.43	58.98	0.38	6,890	S.M. Ry. Co. (1939)
Heng-shan	Lump (No.1)	2.01	14.71	30.10	53.18	0.34	6,903	Seishin Iron Smelter, N. Korea (1943)
Ma-shan	Unscreened	1.03	27.51	21.23	51.10	---	6,140	S.M. Ry. Co. (1942

The estimates of coal reserves of Mi-shan mines as of 1940 are as follows (unit in million ton): Ti-tao 380, Cheng-tzu-ho 430, Heng-shan 650, Chi-hsi 13, Ma-shan 30, totaling 2,003. The annual output of the Mi-shan coal mines follows (in thousands of ton):

Year	Ti-tao	Ma-shan	Cheng-tzu-ho	Chi-hsi	Ma-shan	Total
1937	102	---	---	81	---	183
1938	172	6	3	79	---	260
1939	378	77	57	108	---	620
1940	698	249	190	162	---	1,293
1941	1,008	494	405	259	---	2,166
1942	1,091	599	493	273	24	2,480

⊗6 The Lin-kou coal mine lies northeast of Lin-k'ou station, working a seam 1.1 to 1.3 m thick which includes a 0.1 to 0.3 m marly parting in the middle. The analytical values of coal in the upper part are, ash 12%, heating value 7,050 calories, and those for the lower are ash 36.69% and heating value 5,142 calories. Both are coking. No estimate of reserves is available. Output was about 35 tons a day.

⊗8 Kuang-i coal mine. The so-called Kuang-i coal field is located around the drainage basin of Pai-ts'ao Kou. According to K. OHKI (1950), the Jurassic coal-bearing formation consists, in descending order, of the Leifeng coal-bearing beds (600 m), the Kushan conglomeratic sandstone (180 m), and the Kuangi coal-bearing beds (450 m). This division was later modified by F. KIRITANI to the Maleng coal-bearing beds, a basal conglomerate, and the Chihsi or Mishan coal-bearing beds, respectively. The Leifeng coal-bearing beds contain 2 or 3 workable seams of coal which is low to medium grade bituminous coal and noncoking. The Kushan conglomeratic sandstone (180 m), and the Kuangi coal-bearing beds contain 5 to 7 workable seams of coal which is medium to high grade bituminous and highly coking. The total reserves of the Kuang-i coal field were estimated at 332,280,000 tons, of which 91,350,000 tons are workable. The coal field was hastily surveyed during the Pacific War and was operated by the South Manchuria Railway Company. Construction of the railroad that forks from the Chining - Siachengtze railway was completed on the day the war ended in 1945.

⊗7 Po-li coal mine. No information is available on the coal seams of this district. Due to difficult access, the coal was worked only intermittently by several native pits.

(Gr)1 Liu-mao graphite mine. The mine area consists of crystalline limestone, metagneiss, graphite schist, and intrusive bodies of biotite granite and pegmatite. Crystalline graphite occurs mostly in bedded graphite schist and partly in veins. Crude graphite ore was reported to contain an average of 18%. In 1944, the mine yielded 500 metric tons of crucible graphite and 4,200 metric tons of electrode graphite. Ore reserves are supposedly very large.

(Gr)2 Erh-tao-ho-kou graphite mine. Graphite deposits similar to the above are found near Erh-tao-ho-k'ou where a flotation plant was built during the Pacific War. Production of the plant was not made public.

(L) The Ta-wu-chan [大 五 站] limestone quarry was known to have 2,000,000 tons of workable reserves. Lime was calcined at Ta-wu-chan.

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Table I. Coal-bearing beds of the Mishan series

	⊗1 Ma-leng [馬 稜]	⊗2 Ti-tao [德 道]	⊗3 Heng-shan [橫 山] and Chi-hsi [鷄 西]	⊗4 Ch'eng-tzu-ho [鄭 子 河]
Maleng formation (Uppermost Jurassic) 100 - 700 m	Maleng coal-bearing fm. (Tuffaceous sandstone and shale, 2 - 3 workable coal seams; 750+m thick)	Maleng coal-bearing fm. (Tuffaceous sandstone and shale, no workable coal; 100 - 150 m thick)	Maleng coal-bearing fm. (Tuffaceous sandstone and shale, no workable coal; 100 - 150 m thick)	Maleng coal-bearing fm. (Tuffaceous sandstone and shale, no workable coal; 100 - 150 m thick)
Mishan formation (Upper Jurassic) 180 - 2,400 m		Upper (White to gray arkose, no workable coal) Middle (Mishan coal-bearing beds) (Arkose, shale, sandstone, 2 - 4 workable coal seams) Lower (Arkose, shale, no workable coal) Total thickness, 1,200 - 1,500 m	Upper, 600 - 700 m thick (White to gray arkose, no workable coal) Middle (Mishan coal-bearing beds), 400 - 500 m thick (Arkose, shale, sandstone, 8 - 10 workable coal seams) Lower, 70 - 120 m thick (Arkose, shale, 1 seam of workable coal) Total thickness 1,200 - 1,500 m	Upper (White to gray arkose, no workable coal) Middle (Mishan coal-bearing beds) (Arkose, shale, sandstone, 2 - 4 workable coal seams) Lower (Arkose, shale, no workable coal) Total thickness, 1,200 - 1,500 m

Table I. Coal-bearing beds of the Mishan series (continued)

	⊗5 Ma-shan [馬 山]	⊗6 Lin-k'ou [林 口]	⊗7 Po-li [勃 利]	⊗8 Kuang-i [光 義]
Maleng formation (Uppermost Jurassic) 100 - 700 m	Maleng coal-bearing fm. (Tuffaceous sandstone and shale, no workable coal, 400 m thick)	Maleng coal-bearing fm. (Tuffaceous sandstone and shale, 1 - 2 workable coal seams, and basal conglomerate; 300 m thick)	Maleng coal-bearing fm. (Tuffaceous sandstone and shale, no workable coal; 600 m thick)	Leifeng coal-bearing fm. (Sandstone and shale, 2 - 3 workable coal seams; 600 m thick) Kushan conglomeratic sandstone (Pebbly sandstone; 180 m thick)
Mishan formation (Upper Jurassic) 180 - 2,400 m	Sandstone, shale and conglomerate, intercalated with 3 seams of workable coal Total thickness, 180 m		Upper (main boal-bearing beds) (Arkose, shale, conglomerate, and some workable coal seams) Lower (Arkose and shale) Total thickness, 2,400 m	Kuangi coal-bearing fm. (Sandstone and shale, 5 - 7 workable coal seams)

Table II. Plant fossils of the Mishan series

	Filicales	Ginkgophyta	Coniferales	Cycadophyta
Maleng formation	Cladophlebis denticulata BRONGN. C. exiliformis GRYL. C. lobifolia PHIL. C. takeyamai O. & T. C. triangularis OISHI Coniopteris hymenophylloides BRONGN. C. burejensis (ZALE) SEW. Onychiopsis elongata GEYL. Sphenopteris goepperti DKR. S. suessi KRASS	Baiera manchurica Y. & O. Czekanowskia rigida HR. Ginkgoites digitata HR. G. sibirica HR.	Brachyphyllum sp. Elatocladus manchurica YOK. E. submanchurica Y. & O. Pityophyllum longifolium NATH. Podozamites lanceolatus L. & H. Sphenolepidium sternbergianum DKR.	Nilssonia shaumburgensis(?) N. sinensis Y. & E.
Mishan formation	Filicales Cladophlebis denticulata BRONGN. C. exiliformis GEYL. C. lobifolia PHIL. Coniopteris hymenophylloides BRONGN. Onychiopsis elongata GEYL. Sphenopteris goepperti DKR.	Ginkgophyta Baiera pseudopulchella Y. & O. Czekanowskia manchuriensis Y. & O. Ginkgoites digitata HR. G. sibirica HR. Phenicopsis manchuriensis Y. & O.	Coniferales Elatocladus manchurica YOK. E. submanchurica Y. & O. Pityophyllum longifolium NATH. P. nordenskjordi HR. Podozamites lanceolatus L. & H.	Cycadophyta Nilssonia nipponensis YOK. N. sinensis Y. & E.