GEOLOGIC COLUMN AND UNIT DESCRIPTION

AGE	ROCK UNIT	LITHOLOGY; THICKNESS WHERE KNOWN
QUATERNARY	Alluvium	Qal — Sand, gravel and clay; thickness less than 20 m
	Diluvium	Qd — Sand, clay and gravel; thickness less than 40 m
	Pleistocene basalt	b3 — Flows of doleritic olivine basalt of variable thickness
	EFFUSIVE CONTACT	
TERTIARY	Neogene basalt	b2 — Flows and sheets of augite-olivine basalt; thickness variable
	EFFUSIVE CONTACT	
	Rhyolite	rh — Rhyolite and quartz porphyry
	EFFUSIVE CONTACT	
	Jura-Cretaceous formation?	Mjk — Sandstone and shale; thickness 20 m to 800 m
MESOZOIC	Mishan series	Mju — Upper: Sandstone, shale and coal; thickness 50 m to 1,000 m Lower: Sandstone and conglomerate; thickness less than 500 m
	UNCONFORMITY	
	Pre-Jurassic granite	g2 — Biotite granite, hornblende-biotite granite, pegmatite, diorite, and granite gneiss
	INTRUSIVE CONTACT	
PALEOZOIC	Upper Paleozoic formation	Pu — Hornfels, graywacke, slate, tuff, conglomerate and limestone; thickness less than 1,000 m
	PROBABLE UNCONFORMITY	
PRECAMBRIAN(?)	Precambrian(?) granite gneiss	ggn — Biotite orthogneiss, hornblende-biotite metagneiss, gneissic granite and crystalline limestone
	INTRUSIVE CONTACT	
	Precambrian(?) crystalline schist	sch — Mica-quartz schist, hornblende schist, limestone, biotite gneiss, quartzite, hornfels and phyllite; thickness unknown

(Column not drawn to scale)

UNIT DESCRIPTION

Alluvium, consisting of sand, gravel and clay, covers the remnants of low terraces and the flood plains along the Sung-hua Chiang [松花江] and the Wo-k'en Ho [绰肯河].

Diluvium, consisting mainly of coarse sand and clay, occasionally associated with gravel, covers the remnants of high terraces that fringe the above-mentioned flood plains. Fossils of mammoth are found in the vicinity of Yung-feng-chen [永丰镇].

Flows of doleritic olivine basalt, Pleistocene in age, are found in the area south of the Sung-hua Chiang. T. OGURA (1950) reported four volcanic domes consisting of olivine basalt in the vicinity of Meng-ku-li [蒙古力] (Tung-meng-ku-li and Hsi-meng-ku-li on the map).

Neogene basalt, mainly augite-olivine basalt, occurs as flows and sheets of variable thickness. It was erupted presumably during the Miocene epoch, and is now exposed as cap rocks of hills like those in the districts of Ch'ing-lung Shan [青龙山] and Shuang-ya Shan [双鸭山]. The rock is generally marked with tabular joints.

Rhyolite in association with quartz porphyry intrudes the Upper Paleozoic formation (Pu) and the pre-Jurassic granite (g2) at Lao-t'u Ting-tzu [老土顶子]. The age of the intrusion is probably Cretaceous.

The Jura-Cretaceous formation consists mainly of grayish white arkosic sandstone, rarely intercalated with gray shale. The thickness ranges from 20 m to 800 m, decreasing eastward.

The Mishan series, or the Upper Jurassic formation, constitutes the Fu-chin [富锦] coal field and other minor coal fields along the A-shui-ta Ho [阿水达河] and the T'ou-tao-lan-pang Ho [头道兰棒河]; it is also sporadically distributed in the southwestern part of the map area. The Fu-chin coal field is divided into the western, middle and eastern blocks by two normal faults that strike N-S and throw westward. Structurally, the western block is characterized by a repetition of parallel folds that generally trend from SE to NW, whereas the middle and the eastern blocks are monoclinal and dip to the south.

The Mishan series in the western block of the coal field can be stratigraphically divided into the upper and lower parts. The upper part is an assemblage of sandstone, shale and four seams of coal. The sandstone, amounting to nearly 60 percent of the whole assemblage, is fine- to medium-grained, siliceous or arkosic, and is brownish gray in the weathered surface. The shale, about 40 percent of the assemblage, is dark gray or blackish, and yields many plant fossils near the coal seams. The thickness of the assemblage was measured as 1,000 m in the western block, 300 to 500 m in the middle block, and 200 m in the eastern block. The coal seams are 2.4 m to 0.5 m thick, gradually thinning toward the east. The plant fossils collected from the coal-bearing beds in the western block are as follows: Filicales (Coniopteris hymenophylloides, C. suess, Onichiopsis elongata), Cycadophyta (Nilssonia sp.), Coniferae (Elatocladus manchuria, Pityophyllum longifolium, Podozamites lanceolatus), Ginkgophyta (Czekanowskia rigida, Ginkgoites sibirica, Baiera sp.). On the basis of these fossils, the age of the coal-bearing beds is assigned to Upper Jurassic. The lower part of the section consists of grayish white arkosic sandstone, with conglomerate at the base. It is distributed only in the western block where the thickness is less than 500 m.

The Mishan series in the middle and the eastern blocks lacks the lower part, so the coal-bearing beds rest directly upon the granite gneiss bedrock (ggn).

The coal-bearing beds of the A-shui-ta coal field in the headwaters of the A-shui-ta Ho are composed of sandstone and shale, intercalated with one or two coal seams. The beds, striking E-W and dipping N, unconformably cover the granite gneiss. The Mishan series of the A-shui-ta coal field is probably continuous with that of the Fu-chin coal field, and forms the southern limb of the synclinal structure of the western block of the Fu-chin coal field.

Pre-Jurassic granite is mainly biotite granite and hornblende-biotite granite. The granite north of the Pien-shih Ho [偏石河] locally contains pegmatite and diorite. The age of intrusion is presumably Triassic, because the granite is unconformably overlain by the Mishan series and has contact-metamorphosed the Upper Paleozoic formation as is observed in the drainage area of the T'ou-tao-lan-pang Ho. Granite gneiss, probably derived from this granite, is found locally.

The Upper Paleozoic formation consists of hornfels-like rocks derived from graywacke, clay slate, tuff and conglomerate, and is intercalated with massive crystalline limestone. It is distributed chiefly in the southeastern corner of the map area. The rocks constituting the formation are of marine origin, presumably Permo-Carboniferous in age, and were metamorphosed by the igneous contact of the granite (g2) and the rhyolite (rh). Metagneiss and paragneiss are found locally.

Precambrian(?) granite gneiss consists chiefly of biotite orthogneiss, hornblende-biotite metagneiss, gneissose granite and some lenticular crystalline limestone. It is distributed in the drainage regions of the Ch'i-hu-li Ho [七虎力河], the Pa-hu-li Ho [八虎力河] and the Pien-shih Ho.

Precambrian(?) crystalline schist southwest of Chia-mu-ssu [佳木斯] consists of bluish gray or pinkish mica-quartz schist; a similar rock is distributed along the Ch'i-hu-li Ho. The crystalline schist in the hills south of Ho-nan-ying [湖南营] was reported as bluish gray hornblende schist, containing limestone, biotite gneiss, quartzite, hornfels and phyllite; the schistosity generally trends N-S.

ECONOMIC VALUE

(Au) Placer gold in the Alluvium was worked in the Pa-hu-li Ho and the Ch'i-hu-li Ho basins.

(Au) Auriferous Pleistocene gravel beds in the upper reaches of the Pa-hu-li Ho were prosperously worked by Chinese and Japanese miners at seven places. Of these, Hua-p'i-kou [桦皮沟] and Ta-shih-t'ou-ho-tzu [大石头河子] were famous gold localities in Manchuria.

(⊗) Fu-chin coal field

The coal field was formerly called the Shuang-ya-tzu [双鸭子] coal field. From 1943 to 1945 it was worked under the name Fu-chin coal field by the South Manchuria Railway Co. A railroad for coal transportation was laid in 1945 between the coal field and Ch'ang-fa-t'un [长发屯] station (not shown on the map) near Chia-mu-ssu. The coal is now shipped to the U.S.S.R. by railway via Chia-mu-ssu and by water through the Sungari and the Amur rivers.

The Fu-chin coal, a medium-grade bituminous coal having a low phosphorous content, is the best in Manchuria for iron-smelting and gas-producing. (Water 1.5 - 2%, fuel ratio 1.6 - 2, carbon 82 - 85%, C/H 14 - 16, heat value of pure coal 8,200 - 8,500 cal.) Analyses of the coal revealed the following:

Fixed carbon	51 - 56%	Sulphur	0.24 - 0.52%
Volatile matter	27 - 41%	Nitrogen	0.700 - 1.064%
Water	1 - 1.7%	Heat value	7,000 - 8,000 cal/kg
Ash	less than 10%	Coke	swelling and strongly caking

The western block of the coal field is the most promising, as it contains 4 coal seams, with thickness of 1 m, 2 m, 2 - 2.4 m and 2 m respectively in descending order, and the seam intervals vary from 15 m to 20 m. In the middle block, there are two or three coal seams, varying in thickness from 1 to 2 m. In the eastern block only one or two coal seams are known, with thickness varying from 1 to 2 m.

Probable coal reserves in the western block were reported as 50 million tons in 1945.

(⊗) A-shui-ta coal field

This coal field resembles the Fu-chin coal field in both the lithology of the coal-bearing beds and the properties of coal.

The oil shale occurring near the coal seam has a varve structure and the odor of oil. The results of distillation tests on the shale are tabulated as follows:

	Water distilled (%)	Oil distilled (%)	Tar oxide in oil distilled (%)	Residue distilled (%)	Gas and loss (%)
1	3.76	13.69	6.18	75.00	7.55
2	5.47	8.11	6.30	79.03	7.39
3	8.60	12.04	5.90	68.95	10.41

The crystalline limestone interbedded within the Upper Paleozoic formation (Pu), the granite gneiss (ggn) and the schist (sch) is calcined for lime in several places.

REFERENCES

IWAI, Jun'ichi, 1953, Report on the Fu-chin coal field, in Geology and mineral resources of the Far East, Manchuria, VII-2h: Comp. Comm. Geology and Mineral Res. Far East, Tokyo Geog. Soc.

KIRITANI, Fumio, 1942, Geology along the route from Po-li [勃利] to Pao-ch'ing [宝清]: Unpub. rept. Manchuria Mine Development Co.

NAGAO, Suteichi, 1944, Report on the eastern Fu-chin coal field: Unpub. rept. Manchuria Mine Development Co.

OGURA, Tsutomu, 1950, Volcanoes of Manchuria, in Geology and mineral resources of the Far East, Manchuria, IV-4: Comp. Comm. Geology and Mineral Res. Far East, Tokyo Geog. Soc.

OHKI, Ken'ichi, 1944, Report on the Fu-chin coal field: Geol. Inst. S. Manchuria Ry. Co.

UCHINO, Toshio, 1937, Report on the placer gold deposits at Hei-pei [黑背], Ta-kou [大沟] and vicinities, Sanchiang Province: Geol. Inst., S. Manchuria Ry. Co. Bull., no. 90.

UEDA, Fusao, 1940, Report on the gold placer near Hsiao-shih-tou [小石头]: Manchuria Geol. Soc. Guidebook for Geol. Excursions in Manchuria, no. 6.

WATANABE, Kyūkichi, 1933, Report on the Shuang-ya-tzu-shan coal field, Fu-chin Hsien, Chilin Province: S. Manchuria Ry. Co. Strategic Mineral Res. Survey Comm., Field Party IV (Coal) Rept.

_____, 1933, Report on the coal field in the upper reaches of the Pa-hu-li Ho, Fu-chin Hsien, Chilin Province: S. Manchuria Ry. Co. Strategic Mineral Res. Survey Comm., Field Party IV (Coal) Rept.