GEOLOGIC COLUMN AND UNIT DESCRIPTION

AGE	ROCK UNIT	LITHOLOGY; THICKNESS WHERE KNOWN
QUATERNARY	Alluvium	Sand, clay, and gravel; thickness less than 5 meters
	UNCONFORMITY	
	Diluvium	Qds: aeolian sand and silt and fluvio-lacustrine sand and clay; thickness less than 30 m Qdl: loess, redeposited sandy loess, sand and clay; thickness less than 20 m
	UNCONFORMITY	
TERTIARY	Neogene basalt	Doleritic olivine-augite basalt
	EFFUSIVE CONTACT	
	Neogene formation	Tuffaceous sandstone and conglomerate; thickness 100 m
	UNCONFORMITY	
MESOZOIC	Cretaceous formation	Conglomerate with tuffaceous sandstone; thickness more than 300 m
	UNCONFORMITY	
	Cretaceous rhyolite	Rhyolite with trachyte, andesite, dacite, tuff, sandstone, shale, and breccia; thickness several hundred meters
	Cretaceous andesite	Andesite with trachyandesite, dacite and breccia; thickness less than 100 m
	Cretaceous volcanic complex	Sandstone, shale, breccia and rhyolitic tuff, with flows of rhyolite, trachyte and andesite; thickness 500 m
	UNCONFORMITY	
	Quartz porphyry	
	Granite porphyry	Granite porphyry with porphyritic granite
	Cretaceous granite	Porphyritic biotite granite, two-mica granite, hornblende-biotite granite, and hornblende granite
	Cretaceous diorite	Marginal facies of Cretaceous granite
	Cretaceous basic plutonic rock	Gabbro and hornblendite
	INTRUSIVE CONTACT	
	Jurassic-Cretaceous formation	Shale, sandstone, conglomerate, agglomerate, tuff, and coal; thickness 500 to 1,000 m
	UNCONFORMITY	
	Upper Jurassic formation	Tuffaceous sandstone, shale, conglomerate, and coal; thickness 500 to 1,000 m
	DISCONFORMITY AND UNCONFORMITY	
	Jurassic andesite	Cryptocrystalline andesite with dacite, trachyte, pyroclastic breccia, and andesitic agglomerate
	Jurassic volcanic complex	Andesite porphyry, cryptocrystalline andesite, propylite, diabase, with agglomerate, tuff, sandstone, and breccia; thickness more than 1,000 m
	EFFUSIVE AND INTRUSIVE CONTACT	
	Pre-Jurassic granite	Granular biotite granite
	INTRUSIVE CONTACT	
PRECAMBRIAN	Upper Precambrian formation (Sinian system)	Limestone, phyllite, slate, quartzite, sandstone, and conglomerate; thickness more than 1,000 m
	UNCONFORMITY	
	Crystalline schist (Wutai system?)	Biotite schist and hornblende schist, with limestone (ls) and quartzite (qt)
	RELATION UNKNOWN	
	Gneiss complex	gn: undifferentiated gneisses including metagneiss, orthogneiss and paragneiss mgn: biotite metagneiss, hornblende metagneiss, and hornblende-biotite metagneiss, including injection gneiss, migmatite gneiss and paragneiss ggn: biotite granite gneiss, two-mica granite gneiss, hornblende granite gneiss, and hornblende-biotite granite gneiss, including orthogneiss with some metagneiss and paragneiss

(Column not drawn to scale)

UNIT DESCRIPTION

Alluvium, consisting of sand, clay, and gravel, is distributed along the narrow drainage basins of the Ch'ao Ho[潮河], the Luan Ho[灤河], the Yin-ma-t'u Ho[銀馬圖河]and their tributaries.

Diluvium, Late Pleistocene in age, is divided into Qds and Qdl.

Qds consists of aeolian sand and silt and fluvio-lacustrine sand and clay, and is distributed in the northwestern part of the map area where it constitutes a marginal portion of the Mongolian plateau. It is locally eroded by wind.

Qdl consists of loess and redeposited sandy loess which is interstratified with aeolian sand and clay. The deposit is sporadically distributed in small areas along the rivers.

Neogene basalt occurs as a southeastern extension of the Mongolian plateau basalt which effused during the Miocene and Pliocene. The rock is a doleritic olivine-augite basalt which occurs as superposed flows associated with tuff and breccia.

The Neogene formation near Wei-ch'ang [圍場] consists of light gray tuffaceous sandstone with pebbles in the upper part, and reddish green conglomerate in the lower part. The pebbles of conglomerate, 2 to 6 cm in diameter, are rounded rhyolite, andesite, quartzite and hornstone, cemented with tuffaceous sandstone. The formation horizontally rests on the Cretaceous granite (g3) and the Jurassic volcanic complex (Mjv). The lowermost part of the formation yields plant fossils which are defined as Upper Miocene in age by CHARDIN (1932) and DEPAPE (1932).

The Cretaceous formation, known as the Ch'engte conglomerate, consists of reddish purple conglomerate with thin bedded tuffaceous sandstone. The pebbles of the conglomerate are roundly eroded volcanic rocks ranging in age from Lower Cretaceous to Precambrian. The formation dips gently, less than 10°, although the geologic structure of the underlying formations is irregular. The age of the formation is probably Lower to Middle Cretaceous.

Cretaceous rhyolite, occurring mainly as superposed flows, is sporadically distributed at the tops of the higher mountains. It consists chiefly of rhyolite associated with trachyte, andesite, dacite, tuff, sandstone, shale, and breccia.

Cretaceous andesite, occurring as flows and sheets, is locally accompanied by Cretaceous rhyolite. The rock consists of andesite with trachyandesite, dacite and breccia.

The Cretaceous volcanic complex is disconformably overlain by the rhyolite flows in the southeastern part of the map area. The complex consists of sandstone, shale, breccia, and rhyolitic tuff, locally accompanied by flows of rhyolite, trachyte and andesite.

Cretaceous quartz porphyry near Shang-huang-ch'i [上皇旗] intrudes the pre-Jurassic granite (g2). The rock near La-ma-miao [喇嘛廟]grades eastward into rhyolite, suggesting that it intruded in an age between the Cretaceous granite intrusion and the rhyolite effusion.

Granite porphyry near Kang-ying-tzu [康营子], Ia-tzu Shan[牙子山], Ta-hsi-chia-fang[大西家房], and Ta-ko-chen [大閣鎮] is a differentiated facies of the Cretaceous granite. The rock near Ta-ko-chen intrudes the pre-Jurassic granite.

Cretaceous granite includes medium- to fine-grained porphyritic biotite granite, two-mica granite, hornblende-biotite granite and hornblende granite. It is characterized by porphyritic texture, bearing many phenocrysts of idiomorphic feldspar and bipyramidal quartz. It shows tabular joints in many places such as Kuan-ti [關地] and Wei-ch'ang. The rock is intruded by dikes of pegmatite, aplite, and quartz, which bears no gold. From the fact that the granite is overlain by the Neogene basalt, the Neogene formation, and the Cretaceous rhyolite, andesite, and volcanic complex, and intrudes the Jurassic-Cretaceous formation, the Upper Jurassic formation, and the Jurassic andesite and volcanic complex as well as the Precambrian schists and gneisses, the age of the intrusion may be assigned to an early stage of the Lower Cretaceous.

Cretaceous diorite near Feng-ning [豐寧], Ha-ma-ying-tzu [哈馬營子]and Niang-tzu-kou [娘子溝] is a marginal facies of the Cretaceous granite.

Cretaceous basic plutonic rock, including gabbro and hornblendite, is also a marginal facies of the Cretaceous granite. A leucocratic gabbro at Hei Shan [黑山] is gneissose in texture, consisting chiefly of light gray plagioclase, 7 or 8 cm in diameter, with subordinate augite and hornblende. It is intruded by dikes of melanocratic gabbro which consists of augite, hornblende, titanite and magnetite. A hornblendite near Tieh-ma-t'u-kou[鉄馬土溝] and Po-lo-no [博羅諾] consists of greenish hornblende, chlorite and diopside, with some feldspar.

The Jurassic-Cretaceous formation of the map area corresponds to the upper part of the middle Jehol formation. (1) The formation near Feng-ning consists, in descending order, of conglomerate (100 m thick), green shale interbedded with sandstone and conglomerate (400 m thick), brown shale, interbedded with oil shale, containing fossils such as Cyrena sp. and Baiera sp. in the upper part (425 m thick), black shale with thin coal seams (10 m thick), and light yellow conglomerate and agglomeratic tuff with coal (10 to 20 m thick). The formation dips monoclinally to the northwest, and is intruded by the Cretaceous granite along the northwest boundary. (2) The formation near Ta-ko-chen consists, in descending order, of black shale with a coal seam in the upper part (500 m thick), light gray sandstone (10 m thick), brown shale yielding Estheria sp. (2 m thick), and sandy shale (8 m thick). It rests unconformably on the pre-Jurassic granite. (3) The formation near Kang-yao [紅窯] and Lung-hua [隆化] consists of gray fine- to coarse-grained sandstone, dark gray shale, greenish gray sandy shale, conglomeratic sandstone, conglomerate and coal seams. The former yields many plant fossils, and the latter yields plant fossils and Estheria sp. of Lower Cretaceous to Upper Jurassic in age. The former is surrounded by faults and not intruded by gabbro, and the latter rests unconformably on the granite gneiss (ggn). (4) The formation near Hsin-tien [新店] consists of light gray shale and yields Estheria sp.

The Upper Jurassic formation, corresponding to the lower part of the middle Jehol formation, is sporadically exposed in the northern half of the map area. The formation consists of tuffaceous sandstone, shale, conglomerate and locally thin coal seams. The formation near Kuan-ti [關地], consisting of gray, brown, or purplish red tuffaceous sandstone and basal conglomerate, rests unconformably on the Jurassic andesite (Mja) and is intruded by the Cretaceous granite at Fang-chia-wo-p'u [房家窩鋪]. The coal-bearing formation near Ch'ing-shih-lei [青石磊] rests unconformably on the pre-Jurassic granite along its eastern boundary, and is overlain by Cretaceous rhyolite flows along its western boundary.

The Upper Jurassic volcanics and pyroclastics constituting the lower Jehol formation are disconformably or unconformably overlain by the Upper Jurassic formation and are intruded by the Cretaceous granite. They are subdivided into Jurassic andesite (Mja) and the Jurassic volcanic complex (Mjv).

Jurassic andesite consists of massive flows and sheets of cryptocrystalline andesite, generally associated with dacite, trachyte, pyroclastic breccia and andesitic agglomerate.

The Jurassic volcanic complex or the "greenstone complex" consists of flows and sheets of andesite porphyry, cryptocrystalline andesite, propylite, and diabase in association with andesitic agglomerate, tuff, sandstone, and breccia. The complex is more than 1,000 m in total thickness.

Pre-Jurassic granite, probably Triassic in age, is exposed in the western part of the map area. The rock is gray, medium-grained biotite granite, and is characteristically non-porphyritic in texture. The rock near Ch'in-shih-lei does not intrude the Jurassic formation. Near Ta-ko-chen it is intruded by the Cretaceous granite porphyry. The rock is overlain by the Upper Jurassic formation and the Cretaceous rhyolite and volcanic complex. It is indistinguishable.

The Upper Precambrian formation, or the Sinian system, is exposed only in the vicinity of Shan-wo-p'u [山窩鋪] The upper part consists of limestone, siliceous limestone, alternating siliceous phyllite and calcareous slate, and red slate. The lower part consists of thick-bedded quartzite, argillaceous sandstone, and conglomerate.

The crystalline schist, probably the Wutai system, is sporadically exposed in the southeastern and western parts of the map area. It consists mainly of biotite schist and hornblende schist, and is characteristically accompanied by limestone and quartzite. The exposure in the southeastern part of the map area extends E-W; the northern part consists of biotite schist and the southern part hornblende schist.

The gneiss complex (gn) in the southwestern part of the map area is correlated with the Sangkan gneiss (TEGENGREN, 1921). The complex in the eastern half of the map area is lithologically divided into two units, metagneiss (mgn) and granite gneiss (ggn). The metagneiss extends E-W, and is correlated with the Sangkan gneiss. It consists of biotite metagneiss, hornblende metagneiss and hornblende-biotite metagneiss, including injection gneiss, migmatite gneiss, and paragneiss. The granite gneiss is widely exposed, extends E-W, and is correlated with the Taishan complex. It consists of biotite granite gneiss, two-mica granite gneiss, hornblende granite gneiss and hornblende-biotite granite gneiss, including orthogneiss in association with some metagneiss and paragneiss. Augen gneiss and garnet gneiss are also exposed near Pei-wo-p'u [北窩鋪].

ECONOMIC VALUE

(Deposit numbers refer to localities shown on map)

Asterisk (*) indicates name not shown on map.

Gold

Placer gold occurs in the Recent gravel beds (Qal) and in the Pleistocene terrace deposits (Qdl) along the streams of the gneiss region, especially in the southeastern part of the map area.

Fissure-filling gold-bearing quartz veins intrude the Precambrian gneiss in the following localities where gold was worked previously: Au 1 Nieng-tzu-kou*(娘子溝), Au 2 Lo-to-kou*[駱駝溝], Au 3 Pa-tao-ho-tzu*[八道河子], Au 4 Lao-ch'ien-kou [老牛溝], Au 5 Lwan-chia-ying-tzu*[灤家營子], Au 6 Lao-wo-kou* [老窩溝].

Lead

Fissure-filling quartz veins containing lead and silver intrude the Precambrian gneiss in the following localities: Pb 1 Ya-pa-tien [雅巴店], Pb 2 San-tao-kou [三道溝], Pb 3 Shih-hui-yao [石灰窯].

Copper

Copper-bearing quartz veins occur in two places: Cu 1, Mang-niu-kou*[猛牛溝], 1 km west of Pai-ch'i [白旗] along the Yin-ma-t'u Ho, where a vein 20 cm wide occurs in garnetiferous pegmatite; Cu 2, Lung-feng Shan*[隆風山], 14 km west of Lung-hua, where a vein 30 cm wide occurs in a contact zone between the Precambrian augen gneiss and quartzite. The Cu content is 2.2%.

Iron

A vanadium-bearing titano-magnetite deposit occurs in the basic plutonic rock (r) near Ta-miao [大廟]. The deposit is mineralogically divided into three types as follows:
(1) Ilmenite-magnetite ore. Fe 1, a hill 1 to 2 km northwest of Ta-miao, where 34 ore bodies are found and 16 of which are 18 m in average width and 150 m in length. Fe 2, eastern slope of Hei Shan [黑山], where 11 ore bodies out of 20 are 20 m long. The result of analysis shows the following percentages:

	Fe	SiO_2	Al_2O_3	P	S	TiO_2	Mn	V
Fe 1	53.21	2.22	5.71	0.046	0.091	12.26	0.182	0.11 - 0.33
Fe 2	48.09	5.48	6.38	0.017	0.047	11.20	0.184	0.05 - 0.40

(2) Rutile-magnetite ore (5 ore bodies) in gabbro. Fe 3, a hill 1 km south-southwest of Ta-miao; the ore contains Fe 42 - 50%, TiO_2 9 - 15%, insoluble residue 12 - 20%, and V 0.04 - 0.22%.
(3) Apatite-magnetite ore (8 ore bodies) in hornblendite. Fe 4, near T'ieh-ma-t'u-kou[鉄馬土溝].

Fluorite

Fluorite deposit is found along the boundary between Cretaceous rhyolite and quartz porphyry at Nan-t'ang* [南塘], 16 km northwest of Kuo-chia-t'un[郭家屯].

Building stone

Cretaceous agglomeratic andesite, near La-ma-miao [喇嘛廟] along the Je Ho [熱河], is quarried by the natives as building stone.

Coal

Coal seams in the Jurassic-Cretaceous (Mjk) and Upper Jurassic (Mju) formations are generally too poor in thickness and quality to be worked. The localities and thicknesses are as follows:

Locality	Number and thickness	Strike	Dip
1 Feng-ning	4 (0.05 to 0.05 m)	N 45° E	10 to 20° NW
2 Kang-yao	3 (0.9 to 0.10 m)	N 10° E	45 to 60° E
3 Lung-hua	3 (0.3 to 0.1 m)	N 60 to 70° W	35 to 60° SW
4 Ta-ko-chen	1 (0.2 m)	N 15 to 55° E	25 to 35° SE
5 Ch'ing-shih-lei	5 (0.7 to 0.2 m)	N 80° W	50 to 60° S

Oil shale

Oil shale occurs in the Jurassic-Cretaceous formation at the following two localities:

1. An oil shale bed in the hill 8 km northwest of Feng-ning is 3 m thick, strikes N 40° E and dips 20° to 30° NW. It yields 3.2% crude oil at the distillation temperature of 500° C. Extract of unrefined oil is poor. The reserves estimated by K. UWATOKO (1933) are 5,000,000 tons (proven reserves) and 15,700,000 tons (probable reserves).
2. An oil shale bed near Kang-yao, 18 km southeast of Lung-hua, rests on the coal seam and is 0.6 m thick. Distillation analysis revealed water 8.67%, crude oil 16.33%, residue 71.33% and gas 4.40 l/g. The oil shale is similar in grade to the Fu-shun oil shale.

Asbestos

Asbestos deposits occur in hornblende schist (sch) and hornblendite (r) near Huang-t'u-kan [黃土坎], A 1, along the Je Ho, and near Hung-ch'i [紅旗], A 2, along the Yin-ma-t'u Ho.

Limestone

Lenticular limestone in the Wutai system (sch) is calcined at Shih-hui-yao-kou[石灰窯溝], L 1, 10 km south-southeast of Lung-hua, and at Shih-hui-yao-tzu-kou[石灰窯子溝], L 2, 15 km east of Ta-ko-chen.

Hot springs

(1) Nan-t'ang hot spring, 16 km northwest of Kuo-chia-t'un, gushes out of the boundary between quartz porphyry (qp) and rhyolite (rh). The water is transparent, weakly alkaline, and carburetted. The yield is very large.
(2) Hung-t'ang-ssu (紅湯寺) spring, 16 km southwest of Ta-ko-chen, comes out of the boundary between the pre-Jurassic granite (g2) and the Precambrian gneiss (gn).

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