GEOLOGIC COLUMN AND UNIT DESCRIPTION

AGE	ROCK UNIT	LITHOLOGY; THICKNESS WHERE KNOWN
QUATERNARY	Alluvium	Qal — Sand, clay and gravel; thickness less than 10 meters
	UNCONFORMITY	
	Diluvium	Qds — Sand, clay and gravel; thickness less than 50 m
	UNCONFORMITY	
TERTIARY	Neogene basalt	N — Cryptocrystalline basalt
	EFFUSIVE CONTACT	
MESOZOIC	Cretaceous andesite	Mka — Biotite andesite and biotite-hornblende andesite
	Cretaceous rhyolite	rh — Rhyolite and cryptocrystalline rhyolite
	EFFUSIVE CONTACT	
	Quartz porphyry	qp — Quartz porphyry, granite porphyry and felsophyre
	Cretaceous granite	g_3 — Porphyritic granite or granite porphyry
	INTRUSIVE CONTACT	
	Jurassic formation	MJ — Tuff, breccia, sandstone, shale and hornstone; thickness more than 10 m
	UNCONFORMITY	
	Jurassic andesite	Mja — Biotite andesite and hornblende-biotite andesite
	Jurassic volcanic complex (Greenstone complex)	MJv — Andesite porphyry, diorite porphyry, diabase, dolerite, propylite, andesite, tuff, breccia and sandstone; thickness unknown
	EFFUSIVE AND INTRUSIVE CONTACT	
	Porphyrite	Porphyrite, granite porphyry and diorite porphyry
	Pre-Jurassic granite	g_2 — Biotite granite, two-mica granite, aplite and pegmatite

(Column not drawn to scale)

U N I T D E S C R I P T I O N S

The soil covering the Recent and Pleistocene deposits is composed mainly of "tschernosem", 0.3 to 2.0 m thick, consisting of rich black muck and very fine sand. The black muck is fertile and is especially good for wheat cultivation.

Alluvium, consisting of sand, clay and gravel, is distributed in the drainage basins of the Ken Ho [根河], the Te-erh-pu-erh Ho [得尔布尔河], the Ha-wu-erh Ho [哈乌尔河] and their tributaries, covering flood plains and low terrace remnants. It is covered by black muck 0.3 to 2 m thick. Seven wells revealed the following sequences in descending order (Numbers correspond to localities shown on map):

①Nai-lo-mu-t'u[奈勒穆图], along the Baaruchakon River Black muck ..... 1 m Black clay with sand and gravel ... 1.8+m	②K'u-li-ch'o-wei[库力绰维], 20 km north of Nai-lo-mu-t'u Black muck ..... 1 m Sand with gravel ..... 2 m	③Hsia-wu-erh-ko [下乌尔格] No. 1, 30 km ESE of Nai-lo-mu-t'u Black muck ..... 0.6 m Sand and gravel ..... 4.9 m	④Hsia-wu-erh-ko No. 2 Black muck ..... 0.85 m Sand and gravel ... 3 m Brown clay ..... 1+m
⑤Shang-wu-erh-ko[上乌尔格], 32 km east of Nai-lo-mu-t'u Black muck ..... 0.3 m Black clay with sand and gravel .... 0.5 m	⑥Hsia-k'u-li [下库力] No. 1, 31 km SE of Nai-lo-mu-t'u Black muck ..... 1 m Brownish clay ..... 1.5 m Clay with sand ..... 1.4 m Fine-grained sand with brown clay ..... 2 m Brown clay ..... 2.5 m Black clay with sand .. 2 m Gravel ..... 0.7+m	⑦Hsia-k'u-li No. 2, 31 km SE of Nai-lo-mu-t'u Black muck ..... 1 m Brown clay ..... 1 m Fine-grained sand .... 1 m Coarse-grained sand .. 1.5 m	

Ground water occurs in the gravel bed beneath the black muck. As the water level is high in the flood plains, water of the neighboring rivers must permeate the aquifer. The ground water level of the above-mentioned wells is 2 m at Nai-lo-mu-t'u, 1.75 m at K'u-li-ch'o-wei, 0.55 mat Shang-wu-erh-ko, 1.4 m at Hsia-wu-erh-ko No. 1, 2.2 m at Hsia-wu-erh-ko No. 2, 2.5 m at Hsia-k'u-li No. 1, 1 m at Hsia-k'u-li No. 2, and 2 m at La-pu-ta-jen. Fresh water springs are plentiful. Springs at Shang-wu-erh-ko and Na-erh-mo-ko-ch'i gush out of joints or fissures in the bedrock, and others at Kon-kū-lu, about 13 km southwest of Na-erh-mo-ko-ch'i, issue from the mouth of an inclined plane between the bedrock and a talus bed 1 to 5 m thick. The spring water is abundant and good in quality.

Diluvium, consisting of sand, clay and gravel of aeolian-fluvio-lacustrine origin, is distributed on the southern bank of the Ken Ho. It is covered by Recent dune sand, 0.5 - 3 m thick, or by black muck 0.4 to 2 m thick.

Neogene basalt is exposed in the hilly land along the Ken Ho, stretching east-northeast throughout the map area. It consists chiefly of black or dark gray cryptocrystalline compact trap-type basalt. Under a microscope it shows a granular structure, containing microcrystals of augite and feldspar, and rare microphenocrysts of olivine and augite.

Cretaceous andesite occurs as flows and is widely distributed in the northern part of the map area. It is a deep or light green, massive, compact, porous rock showing a fluidal structure, and consists mainly of biotite andesite and some hornblende-biotite andesite. It is overlain by the Neogene basalt and rests on the Cretaceous rhyolite (rh), the Jurassic formation (Mj), and the Jurassic volcanic complex (Mjv). The western boundary between the andesite and the pre-Jurassic granite (g_2) along the Derubukan Ka is probably cut by a fault having an eastward throw.

Cretaceous rhyolite occurring in the southern half of the map area and in the hills north of the Te-erh-pu-erh Ho consists of an aggregation of rhyolite proper and cryptocrystalline rhyolite; obsidian is found in the upper reaches of the Baarchakon-ka. It is overlain by the Cretaceous andesite and the Neogene basalt, and rests on Cretaceous granite (g_3), the Jurassic formation, Jurassic andesite (Mja), the Jurassic volcanic complex, quartz porphyry (qp) and pre-Jurassic granite.

Cretaceous quartz porphyry, including granite porphyry and felsophyre, is sporadically exposed. The rock is generally reddish brown to yellowish brown, and consists of phenocrysts of quartz and reddish orthoclase, with a holocrystalline groundmass; colored minerals are scarce but biotite occurs rarely. The rock exposed 8 km northeast of Ja-pu-ta-jen [拉布大仁] along the Ken Ho is felsophyre, and rests on the Jurassic formation. The Jurassic formation at Ashinōka-san, Shang-wu-erh-ko, and I-erh-k'a-shih Ho and the Jurassic volcanic complex in the hills south of the Ken Ho were contact-metamorphosed by the quartz porphyry. It may be a marginal facies of the Cretaceous granite, and is locally intruded by quartz veins which contain fluorite.

Cretaceous granite occurs in small areas. It consists chiefly of porphyritic granite or granite porphyry containing phenocrysts of reddish, nearly idiomorphic microcline and idiomorphic to hypidiomorphic quartz; colored minerals are scarce. The rock 5 km southeast of Tu-po-wei [杜博维] had contact-metamorphosed the Jurassic volcanic complex. It was probably intruded prior to the intrusion of the Cretaceous quartz porphyry.

The Jurassic formation is sporadically distributed along the Te-erh-pu-erh Ho and the Ken Ho. As it yields no fossils, whether it is Jurassic or Cretaceous in age is unknown. It consists of an aggregation of tuff, breccia, sandstone, shale, and hornfels. The exposures are summarized below.

	Locality	Lithology	Strike and Dip	Geology
Along the Te-erh-pu-erh Ho	Ashinōka-san between the Daiichi-wakārachiya-dani and the Cherebin-ka	Yellowish tuff, gray fine-grained sandstone and tuffaceous breccia	N 20° E; 20° E or W	The formation is intruded by quartz porphyry; repeatedly folded.
	Southern bank of the Te-erh-pu-erh Ho near the Daisan-wakārachiya-dani	Tuffaceous sandstone	E; 30° S	Intruded by Jurassic volcanic extrusives.
	Northern bank of the Te-erh-pu-erh Ho near the Karagayadani and Seki-chiendani	Tuffaceous sandstone	E; 30° S	Overlain by Cretaceous andesite.
	Northern bank of the Te-erh-pu-erh Ho near the Nijineyabiriyādani	Tuff, tuffaceous breccia and sandstone		Overlain by rhyolite flows.
Along the Ken Ho	Hill west of the I-erh-k'a-shih Ho[依额喝什河]	Alternation of reddish brown sandstone, conglomeratic sandstone and conglomerate	N 45° W; 20° NE	Intruded by Cretaceous quartz porphyry.
	Cliff 8 km NE of La-pu-ta-jen	Sequence in descending order: (d) Grayish green tuff (c) Alternation of hornfels and shale (b) Shale (a) Grayish tuffaceous sandstone	N 75° E; 30° S	About 10 m thick; overlain by felsophyre.

Jurassic andesite occurs as flows and sheets in the western part of the map area. It is black or gray compact cryptocrystalline biotite andesite or rarely hornblende-biotite andesite having no visible phenocrysts. In places it is accompanied by the "greenstone complex". Megascopically the andesite resembles the black cryptocrystalline basalt of Neogene age. Under a microscope, the groundmass shows an andesitic structure, bearing microphenocrysts of biotite and hornblende.

The Jurassic volcanic complex, or "greenstone complex", is a complicated assemblage of black, purple or dark green intermediate igneous intrusives and extrusives. It includes andesite porphyry, diorite porphyry, diabase, dolerite, propylite, andesite, tuff, breccia and sandstone. The extrusive rocks of the complex are overlain by the Jurassic andesite (Mja), the Jurassic formation, the Cretaceous rhyolite, the Cretaceous andesite (Mka), the pre-Jurassic granite and the Pleistocene and Recent deposits, and are intruded by the Cretaceous granite and the quartz porphyry; the intrusive rocks had contact-metamorphosed the pre-Jurassic granite, the Jurassic andesite and the Jurassic formation.

Gray porphyrite, associated with granite porphyry and diorite porphyry, is exposed along the southern margin of the pre-Jurassic granite. Phenocrysts of orthoclase and plagioclase are scattered in the groundmass. It is probably a marginal facies of the pre-Jurassic granite.

Pre-Jurassic granite is exposed in the northwestern corner of the map area. It consists chiefly of coarse-grained biotite granite containing phenocrysts of light reddish orthoclase and quartz, and locally two-mica granite. In places the granite is accompanied by fine-grained aplite and pegmatite. The pegmatite is exposed on the top of a hill 15 km north-northwest of Tu-po-wei along the Te-erh-pu-erh Ho.

E C O N O M I C V A L U E

Gold

(1) Placer gold occurs in the uppermost reaches of the Wu-erh-ko Ho[乌尔格河], 13 km east-northeast of Shang-wu-erh-ko, near Keh-pi-shing-k'o (not shown on map). The deposit was prospected by a pit 8 m deep, but was not worked due to poor quality and difficult access. (2) A gold-bearing fluorite-quartz vein is found in a south hill of I-erh-k'a-shih. The vein contains 4 gr per ton gold and 5 gr per ton silver, which suggests that fluorite-quartz veins of other localities may be accompanied by gold and silver.

Oil

Oil shows are found in the marshy land of the flood plain 10 km northeast of Shang-wu-erh-ko along the Wu-erh-ko Ho, and on the northern bank of the Te-erh-pu-erh Ho near Tu-po-wei. Geology of the two places consists of Neogene basalt and Jurassic andesite. According to natives, oil floats on the marshy land, giving a petroliferous odor when it has not rained for many days, although evidence to verify their story is not available.

Potter's clay

(1) Nai-lo-mu-t'u: Whitish porcelain clay is found in the cliff 5 km east-northeast of Nai-lo-ma-t'u, 10 m above the neighboring flood plain. It is a weathering product of rhyolite.
(2) Hsia-wu-erh-ko: Whitish porcelain clay similar to the above occurs in the hill north of Hsia-wu-erh-ko, although access to the locality is difficult.

Fluorite Fluorite deposits occur chiefly in quartz or calcite veins intruding the Jurassic andesite (Mja), the Jurassic formation (Mj), the Cretaceous quartz porphyry (qp), and rarely rhyolite (rh). Fluorite veins filling the fissures of these mother rocks are also found in places. The deposits were formed probably after the effusion of the Cretaceous rhyolite, and before that of the Cretaceous andesite.

(1) Hill east of Nai-lo-mu-t'u:

Geology: The ore deposits occur in the quartz veins intruding gray or grayish brown andesite, locally agglomeratic andesite, having schistosity striking N 60° E and dipping 60° NW. The veins are 10 to 20 m wide, striking E-W and dipping sharply northward. Known length of the exposure is 550 m.

Ore: (A) Western ore:- Rich fluorite ore occure near the foot wall of the quartz vein. It is 156 m long, 2 to 6 m wide, strikes N 80° E and dips 55° N. The boundary between fluorite and quartz is easily distinguished. The ore is a very regular fissure-filling deposit which is rare in Manchuria. According to MONDEN (1943), the estimated grade at the outcrop ranges from 75 to 85%. (B) Eastern ore:- Four parallel fluorite veins are found, striking N 80° W and dipping 80° N. The four veins are: Vein No. 1 (northernmost vein), 95 m long, 1.57 m wide; Vein No. 2 (northern vein), 75 m long, 2.16 m wide; Vein No. 3 (southern vein), 75 m long, 2.83 m wide; and Vein No. 4 (southernmost vein), 40 m long, 0.4 m wide. Each has a grade of 80 to 85%. The northernmost vein is a fissure-filling deposit, and the other three veins are simple fluorite veins.

Quality: Fluorite, occurring as hexagonal crystals, is white, light red or light purple. Locally it occurs in a crystalline compact massive ore body. The average grade of crude ore is about 85%. Analyses of the western crude ore sampled at a 30 m interval show the following results.

Samples numbered eastward	No. 1	No. 2	No. 3	No. 4	No. 5
CaF_2 (%)	97.59	93.12	89.53	96.63	91.95
SiO_2 (%)	1.00	5.04	9.40	1.94	6.70

Mineral reserves: The probable mineral reserves of crude ore having 80% grade were estimated by MONDEN as follows:

Locality	Average width	Probable reserves	Workable ratio	Extraction ratio	Workable reserves
Western ore	2 m	25,800 tons	80%	80%	16,500 tons
Eastern ore	3 m	22,200 tons	80%	80%	14,300 tons
Total	--	48,000 tons	--	--	30,800 tons

(2) Hill north of Nai-lo-mu-t'u: A typical fissure-filling fluorite deposit is exposed 4 km northwest of Nai-lo-mu-t'u, in the Jurassic andesite. The vein strikes N 60° E, dips vertically, and is 90 m long, with a variable width ranging from 1.5 m to extinction. Analysis of the ore shows an average of 95.39% CaF_2, 3.16% SiO_2 and 0.026% $BaSO_4$.

(3) Na-erh-mo-ko-ch'i[那额莫格奇]: Several parallel veins of quartz and fluorite intruding the Jurassic cryptocrystalline andesite are exposed in a cliff 2 km northwest of Na-erh-mo-ko-ch'i. The outcrop is 210 m long, 1.5 to 3 m wide, strikes N 20° W and dips 75° E. The quartz veins show a banded structure and contain topaz and light red or light green fluorite microcrystals. Fluorite veins are very irregular in form, lenticular, nodular, platy, or occur as divergent ore bodies in fissures in the quartz veins. The veins are 170 m long, 33 m high, 0.5 m wide, and have a specific gravity of 3.2. According to MONDEN the probable mineral reserves of crude ore is only 4,230 tons, the grade of which is 90%. The workable mineral reserves aggregate 3,200 tons.

(4) Kon-kū-lu, 15 km SW of Na-erh-mo-ko-ch'i: Several parallel fluorite-quartz veins in the quartz porphyry are exposed in a hill 2 km northeast of Kon-kū-lu. They strike N 40° - 60° E, dips vertically, and is 60 m long and 2 m wide. Quartz veins were impregnated by fluorite crystals.

(5) Hill north of I-erh-k'a-shih[依额喝什河]: Two parallel fluorite-quartz veins intruding the Jurassic formation are exposed 10 km north-northwest of I-erh-k'a-shih. The formation consists of an alternation of reddish brown sandstone and conglomerate. The vein contains fluorite with a grade of 30%, which is difficult to separate from quartz.

(6) Hill between the headwaters of the K'u-li Ho and the I-erh-k'a-shih Ho: A lenticular fluorite-quartz vein intruding quartz porphyry is exposed in a hill 5 km southwest of I-erh-k'a-shih (not shown on the map). It stretches for a length of 30 m, with a width 1 to 1.5 m, strikes E and dips vertically. The fluorite ore is poor in quality and reserves, but the quartz vein contains gold and silver.

(7) Hsia-k'u-li: Many small fissure-filling veins are found in andesite in the hill east of Hsia-k'u-li. The mother rock is sugite andesite containing abundant agates and opal. The veins are generally less than 4 cm in width. A fluorite-bearing calcite vein occurs in the neighboring hill; it is 50 m long, 40 cm wide, strikes N 64° W and dips vertically.

(8) Pao-ko-lo-fu-k'a[包格洛夫卡] and Ja-pu-ta-jen[拉布大仁]: Many small veins filling the fissures of rhyolite are found near Pao-ko-lo-fu-k'a, and some occurring in andesite are found near Ja-pu-ta-jen, although both quality and quantity are poor.

Agate, topaz and opal

Topaz and opal occur in the fluorite-quartz veins at Na-erh-mo-ko-ch'i. Agate and opal are found to fill the fissures of andesite in the hill east of Hsia-k'u-li. The amount of these semi-precious stones is small.

Lead and silver

The Biriya lead and silver mine is located 75 km northeast of Nai-lo-mu-t'u. Galena was formally worked by Russians.

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