GEOLOGIC COLUMN AND UNIT DESCRIPTION

AGE	ROCK UNIT	LITHOLOGY; THICKNESS WHERE KNOWN	UNIT DESCRIPTION	ECONOMIC VALUE
QUATERNARY	Alluvium (Qal)	Clay, sand and gravel; thickness less than 30 meters	Alluvium is distributed in the drainage basins of the Amur River, the K'o-lo Ho and their tributaries, covering flood plains and low terrace remnants. It consists chiefly of clay and sand in the upper part and sand and gravel in the lower part. It is generally covered by marshes and black muck resulting from the high ground water level. Drillhole records revealed the following sequence in descending order: Hsi-ho-lo-mo-ching (西窩勒謨泽): Black muck 0.5 m; Clay and silt 20.0 m; Coarse quartz sand with gravel 10.0 m Ai-hun (瑷琿): Black muck 0.5 m; Clay and silt 10.0 m; Fine sand and gravel 5.0 m Hei-Ho (黑河): Black muck 0.5 m; Clay 5.0 m; Sand and gravel 5.0 m Sheet NM52-4: Hsi-kou (西溝): Black muck 0.3 m; Clay 5.0 m; Gravel 5.0 m Alluvium in the upper reaches of the rivers consists of sand with large boulders 0.3 to 0.5 m in diameter, and is less than 7 m thick. The ground water level in wells along the Amur River lies generally at 5 m to 20 m below the surface. As it is closely related to the surface water level of the Amur River, a great quantity of water is obtainable. The well of Ai-hun station, with a 150 mm casing, produces 3.7 tons of water per hour from an aquifer at a depth of 15 m. The water is good quality, containing no iron or manganese. The Hsing-hsing-an-ling(小興安嶺) region including Ch'en-ch'ing, Erh-chan and T'a-ch'i abounds in good ground water at shallow depths.	Placer gold (Qal) (1) Placer gold is widely distributed in the drainage basins of the Amur River and its tributaries. The gold-bearing gravel bed, 45 cm thick, at Huang-chi-ying-tzu(荒雞營子) south of Ai-hun, lies below non-auriferous gravel bed 0.3 to 3 m thick. It was formerly worked by Chinese only in the summer season, because the area is entirely frozen during winter months. The output of gold obtained from the gravel bed near Ssu-chi-t'un 四季屯 was estimated at about 4.5 gr per day by one team of six workers. (2) Placer gold is found along the lower reaches of the Ssu-nao Ho(司訥河) 30 km northwest of T'a-ch'i. Gold was derived from the decomposed auriferous quartz veins that intrude the diorite porphyry of the Jurassic volcanic complex.
	UNCONFORMITY			
	Lava cone basalt (b3c)	Augite olivine basalt	Basalt, forming lava cones, each having a crater on top, is exposed at Ma-no-nan Shan(沐納南山), Ka-ts'ung Shan(喀蔥山) and I-chia Shan(一架山). These lava cones probably were erupted in the Recent epoch, covering the plateau basalt (b_3) and the Neogene formation (Tu). They are aspiconite, aspitholoide and asphcnate. The lava is dark gray, compact basalt consisting essentially of augite, olivine and glass, associated with anorthoclase and magnetite.	
	EFFUSIVE CONTACT			
	Lava plateau basalt (b3)	Olivine basalt	Quaternary basalt, forming lava plateaus, is widely exposed in the northwestern and southwestern parts of the map area. The age of eruption ranges from Pleistocene to Recent. The basalt covers the Paleozoic formation (P), the pre-Jurassic granite (g_2), the Cretaceous formation (Mk), the Neogene formation (Tu) and, locally, the Pleistocene deposit (Qdg), and is overlain by the cone lava basalt. The rock is black or pitch black, holocrystalline to holohyaline, and has an intersertal or radial texture. It is hard and compact when fresh, and is porous, containing distinct phenocryste of olivine. The groundmass consists of anorthoclase, plagioclase, olivine, magnetite and glass, occasionally associated with microcrystals of augite, biotite and titaniferous minerals. The combined thickness of b_3c and b_3 may exceed 100 meters.	
	EFFUSIVE CONTACT			
	Diluvium (Qdg)	Clay, sand and gravel; thickness 20 to 40 m	Diluvium consists of yellowish brown sandy clay in the upper part, yellowish brown sand in the middle part, and sand and gravel in the lower part. The total thickness is 20 to 40 m in the southern area along the Hsün Ho(逊河) and 30 to 40 m near Yeh-chi-ti-ying-tzu(葉記地營子) in the north. The test hole at Ch'en-ch'ing (陈清) station revealed the following sequence, in descending order: Recent fluvial deposit (5 m), coarse sand (4.4 m), sandy clay (10 m), basalt lava flow (5.2 m), sand and gravel (11.2 m), and granite bedrock, the total thickness being 21.6 m. Pebbles of the gravel, ranging in size from 1 cm to 15 cm, are andesite porphyry, basalt, quartzite and granite. Abundant ground water is contained in the diluvium, in localities discussed under the unit description of Alluvium, above.	
	UNCONFORMITY			
TERTIARY	Neogene formation (Tu)	Shale, sandstone, gravel and lignite; thickness less than 50 m	The Neogene formation consists of clayey shale, soft sandstone, and gravel, intercalated with bentonitic shale and low grade lignite. The formation is correlated with the Pliocene continental deposits exposed widely in the U.S.S.R. The formation 5 km south of Hsi-ho-lo-mu-ching consists of conglomerate. Distinguishing between the Neogene formation and the overlying Pleistocene deposit (Qdg) may be difficult with no fossils to determine age because of similar lithology.	
	UNCONFORMITY			
	Neogene basalt (b_2)	Doleritic basalt	Neogene basalt is distributed in the southeastern part of the map sheet, in the central part near Erh-chan(二站), and in the northwestern part of the map area, and forms a gently undulating lava plateau larger than the Quaternary lava plateau. It is covered by the Pleistocene deposit (Qdg), the Neogene formation (Tu), and the Quaternary basalt (b_3). The rock is dark gray to dark brown, rough and coarse-grained when fresh. It consists of olivine phenocryste, not visible to the naked eye, and the groundmass consists of microcrystalline augite and olivine. It is generally holocrystalline and doleritic in texture. The lithologic differences between the Neogene basalt and the Quaternary basalt are tabulated below. Rock: b_3 — Color: Black to pitch black — Fresh surface: Hard and compact — Porosity: Mainly porous — Phenocrysts: Olivine, visible — Microcrystals: Olivine, rarely augite — Crystallinity: Holohyal ine to holocrystalline — Texture: Intersertal or radial — Relation to other beds: Overlies Qdg Rock: b_2 — Color: Dark gray to dark brown — Fresh surface: Rough and coarse-grained — Porosity: Somewhat porous — Phenocrysts: Olivine, invisible, rarely with augite — Microcrystals: Olivine and augite — Crystallinity: Holocrystalline — Texture: Doleritic — Relation to other beds: Underlies Qdg and Tu	
	EFFUSIVE CONTACT			
	Paleogene formation (T1)	Sandstone, shale, conglomerate and coal; thickness more than 36 m	The Paleogene coal-bearing formation is exposed at I-chia Shan near Ssu-chi-t'un(四季屯), where the thickness is 36 m or more. The sequence in descending order is as follows: surface soil (+ 1 m), alternating fine-grained sandstone and clayey shale, each 1 m thick (+ 10 m), yellow fine-grained conglomeratic sandstone (+ 10 m), and crossbedded conglomerate (+ 16 m). The formation strikes N 60° W and dips 30° NE or almost horizontally. It is correlated with the Wu-yün formation(烏雲層) of Late Eocene to Miocene age.	Coal (T1, M3) (1) A Paleogene coal-bearing bed is exposed at 400 m southwest of Sung-chia-t'un, beneath the Pleistocene deposit. The coal is low grade lignite. One of the lignite seams is 0.6 m thick. (2) A coal seam along the La-t'an Ho(拉炭河), 30 km south of Ai-hun, was formerly worked by Chinese. (3) A coal-bearing bed, probably Jurassic or Paleogene, is exposed near Sung-shu-kou(松樹溝), 15 km west of Ai-hun, consisting of sandstone, shale, conglomerate and thin coal seams. The coal is poor both in quality and reserves. (4) A coal-bearing bed exposed near Nan-erh-liang(南二龍), 40 km southwest of Ai-hun, was reported to be intercalated with coal seams of good quality, but no details are available.
	UNCONFORMITY			
MESOZOIC	Cretaceous andesite (Mka)	Flows of basaltic augite andesite; thickness unknown	The map unit of Cretaceous andesite consists of flows of basalt and augite andesite. The rock at Hsi Shan (西山) near T'a-ch'i(塔奇) is purplish brown basalt associated with agglomerate. The rock in the vicinity of Liang-chi-t'un(梁集屯) is black, hard and compact basaltic augite andesite showing platy joints; the phenocrysts are plagioclase and augite, and the groundmass consists of microcrystalline plagioclase, augite and magnetite.	
	EFFUSIVE CONTACT			
	Cretaceous rhyolite (rh)	Flows of rhyolite; thickness unknown	The Cretaceous rhyolite occurs as flows and is exposed in many places. The rock on a hill 20 km west of Erh-chan is light grayish brown to pinkish brown, compact, hard and trachytic in texture. It shows marked oblique joints. Under a microscope, a small quantity of quartz phenocrysts are found to be rounded due to corrosion; orthoclase phenocrysts are replaced with secondary quartz and muscovite by silicification; the groundmass shows a perlitic structure. It rests on the pre-Jurassic granite (g_2) and the Paleozoic formation (P), and is overlain by the Neogene basalt (b_2) and the Quaternary basalt (b_3). The rock on a mountain 4 km south of T'a-ch'i rests on the crystalline schist (sch). It is a light brown rhyolite, consisting of phenocrysts of rounded quartz and corroded feldspar with a groundmass showing flow structure. The rock at Ta-chia-tzu(大岔子) overlain by the Neogene basalt is a brown rhyolite containing visible phenocrysts of smoky quartz.	
	EFFUSIVE CONTACT			
	Cretaceous(?) formation (Mku, Mk)	Sandstone, shale and conglomerate; thickness unknown	The Cretaceous(?) formation (Mk) is exposed in the following places. The formation at Hsien-niu-kou (陷牛溝) 5 km north of T'a-ch'i consists of arkosic sandstone and conglomerate. Pebbles of the conglomerate are rounded granite, quartzite and limestone, 3 to 5 cm in diameter, cemented by fine-grained arkose sand. The formation strikes N 40° E and dips 20° SE. The formation near P'ing-ting-shu(平頂樹) consists of sandstone, shale and conglomerate. The formation in the vicinity of Gil'chin is defined as Upper Cretaceous (Mku) by Soviet geologists, although available data are very few.	
	UNCONFORMITY			
	Jurassic(?) formation (MJ)	Sandstone, shale, conglomerate and coal; thickness unknown	The Jurassic(?) coal-bearing formation is sporadically exposed in small patches along the Amur River. It consists of sandstone, shale, conglomerate and low grade coal, although detailed information is not available.	
	UNCONFORMITY			
	Jurassic volcanic complex (Greenstone complex) (MJv)	Diorite porphyry, andesite porphyry, diabase, dolerite, propylite, andesite, rhyolite, tuff, volcanic breccia and sandstone; thickness unknown	The Jurassic volcanic complex, or the so-called Greenstone complex, is an intricate assemblage of black, purple or dark green intrusives and extrusives, such as diorite porphyry, andesite porphyry, diabase, dolerite, propylite, andesite, black rhyolite, tuff, volcanic breccia and sandstone. The complex near Ch'ing-chi(清溪) is greenish black and compact, owing to chloritization, propylitization and silicification. Where it occurs as flows, it is overlain by the Neogene basalt (b_2), the Neogene formation (Tu) and the Pleistocene deposit (Qdg), and it covers the erosion surface of the pre-Jurassic granite (g_2), but where it occurs as sheets it intrudes the Paleozoic formation (P) and the pre-Jurassic granite.	
	EFFUSIVE AND INTRUSIVE CONTACT			
	Granite porphyry (gP)	Marginal facies of pre-Jurassic granite	Granite porphyry, exposed on the eastern hill of Shih-ku Shan(石鼓山), is probably a marginal facies of the pre-Jurassic granite.	
	Pre-Jurassic granite (g_2)	Biotite granite, biotite-hornblende granite and two-mica granite	The pre-Jurassic granite occurs as a batholith or laccoliths and intrudes the Paleozoic formation. The granite in the western part of the map area is light gray or pinkish gray, coarse-grained, consisting chiefly of feldspar with small amounts of quartz, hornblende, biotite, and rarely two micas, and is more or less schistose. The rock near Hsi-kou(西溝) is a medium- to fine-grained biotite granite.	
	Diorite (d)	Marginal facies of pre-Jurassic granite	The diorite, probably a marginal facies of the pre-Jurassic granite, occurs as laccoliths and is exposed in two small areas. The diorite near Shih-wu-li-wan-tzu(十五里湾子), 7 km east of T'ai-ch'i, is associated with quartz diorite. It is dark green and consists chiefly of plagioclase and some hornblende, showing marked oblique joints. Another exposure is found on a hill in the upper reaches of the Mai-hai Ho(埋海河).	
	Gabbro (go)	Marginal facies of pre-Jurassic granite	The gabbro, probably a marginal facies of the pre-Jurassic granite, occurs as laccoliths and is exposed in two small areas. The rock on a hill 7.5 km northeast of Tou-kou-tzu(陡溝子) is a dark gray gabbro containing minute crystals of pyrite. It intrudes the crystalline schist (sch) and is overlain by the Neogene formation (Tu). The gabbro near Shih-ku Shan is dark grayish brown, consisting of brown plagioclase and other colored minerals such as biotite and augite, accompanied by magnetite and apatite. The plagioclase shows albite-twins. The rock intrudes the Paleozoic formation (P) and is overlain by the Quaternary basalt (b_3).	
	INTRUSIVE CONTACT			
PALEOZOIC	Paleozoic formation (P)	Clay slate, graywacke, quartzite, crystalline limestone and hornfels; thickness less than 500 m	The Paleozoic formation consists chiefly of clay slate and graywacke, locally associated with quartzite, crystalline limestone and hornfels derived from phyllite. Shale and sandstone are found where igneous activity was not severe. The formation near Hsi-kou strikes NE and dips generally 10° to 15° SE.	
	RELATION UNKNOWN			
AGE UNKNOWN	Gneiss (gn)	Paragneiss	The gneiss along the Nan-ch'a-tzu Kou(南岔子溝) is a light green, fine- to coarse-grained paragneiss derived from metamorphosed sediments of unknown age, and is more or less schistose. The gneiss in a hill 5 to 10 km northeast of T'a-ch'i is associated with chlorite-hornblende schist.	
	Crystalline schist (sch)	Mica schist, chlorite schist, hornblende schist, quartz schist and talc schist	The crystalline schist of unknown age is exposed in the following three places. The rock near T'ai-ch'i is marked with schistosity, comprising sericite schist, epidote-chlorite schist, hornblende-chlorite schist, chlorite schist, chlorite-quartz schist and talc-chlorite-hornblende schist. The rock near Sung-chia-t'un(宋家屯) comprises chlorite schist, hornblende schist and biotite schist; the schistosity strikes N 30° to 40° E and dips 40° NW. The rock near Tou-kou-tzu is a light green chlorite-hornblende schist or talc-chlorite schist, associated with phyllite.	

(Column not drawn to scale)

REFERENCES

IMAIZUMI, Rikizô, 1952, The Tertiary period of Manchuria, in Geology and mineral resources of the Far East, Manchuria, III-9a: Comp. Comm. Geology and Mineral Res. Far East, Tokyo Geog. Soc.

NALIVKIN, D. V., editor, 1955, Geological map of U.S.S.R., scale 1:5,000,000: U.S.S.R. Ministry of Geology.

SAITÔ, Rinji, compiler, 1940, Geological map of Manchuria and adjacent areas, scale 1:3,000,000: Manchoukuo Geol. Inst.

SHIOTA, Isao, 1935, Geology and geography along the route Hei-ho(黑河) --- Erh-chan(二站) --- Ku-chi Gold Mine(古溝金廠) --- Hei-ho: Unpub. rept., Geol. Inst., S. Manchuria Ry. Co.

USHIMARU, Shutaro, and others, 1937, Geology and geography of northern Manchuria: Geol. Inst., S. Manchuria Ry. Co.