

GEOLOGIC COLUMN AND UNIT DESCRIPTIONS

AGE	ROCK UNIT	LITHOLOGY, THICKNESS WHERE KNOWN	REMARKS	UNIT DESCRIPTION	REFERENCES																								
QUATERNARY	Alluvium	Clay, sand and gravel; thickness less than 15 meters	Alluvium, consisting of clay, sand and gravel, is distributed in the drainage basins of the Amur River, the Ni-ch'i-ho (尼奇河), and their tributaries. In the flood plain of the Amur River it is covered by vast marshy grasslands with black muck 50 cm thick. A drillhole at Hei-ho revealed the descending sequence as follows: black muck (0.5 m), clay (5 m), and sand and gravel (5 m). The ground water level along the Amur River is generally 5 to 20 m below the surface. Water occurs in the sand and gravel beds. The water of the Amur River permeates the aquifer. Water is abundant and good in quality, and contains no iron or manganese. The ground water level in the Hei-ho-ching-an-ling Shan-no is very shallow resulting in wide marshes, especially near the waterbeds. Water is abundant and good in quality.	GOLD Placer gold occurs in the Recent deposits along many of the rivers in the map area.	Geological Institute, South Manchuria Railway Company, 1936, Geological map of Manchuria, scale 1:1,000,000. 1938, Map of North Manchurian mineral resources, 1:500,000. (Unpub.)																								
	Quaternary basalt	Olivine basalt; thickness less than 100 m	Quaternary basalt is black to pitch black, holocrystalline, showing an interstitial or radial texture. The rock is hard, compact and porous, and contains visible phenocrysts of olivine in association with orthoclase, plagioclase, olivine, magnetite, glass and microcrystals of apatite, biotite and titaniferous minerals. The basalt forms a plateau on the southern margin of the map area. It was probably effused during the Pleistocene and the Recent.	The most promising placers are located in the upper reaches or near the waterbeds of the Fa-pieh-la Ho and the Ni-ch'i-ho Ho, and occur in the Recent deposits underlain mainly by the pre-Jurassic granite. During 6 years from 1922 to 1927 inclusive the estimated total production of gold along the Fa-pieh-la Ho was 43,400 kg. Gold-bearing gravel beds contained 6.4 gr of gold per cubic yard on an average. The placers are described in detail below.	KOBAYASHI, Teichu, and NOMAKA, Jun'ichi, 1942, On the Manchu group. Jour. Geography Tokyo, v. 54, no. 643. NALLIVKIN, D. V., editor, 1955, Geological map of U.S.S.R., scale 1:25,000,000. U.S.S.R. Ministry of Geology.																								
	Illuvium	Sand, clay and gravel; thickness 20 to 50 m	Illuvium, consisting of sand, clay and gravel, is exclusively exposed on the east bank of the Zoya River. During the Pleistocene, before the upheaval of the Hei-ho-ching-an-ling Shan-no (小興安山), the old Zoya River flowed toward Pei-an.	(1) Wu-tao-kou (P'ing-yuan Gold Mine 平遠金礦). The drainage basin of the Wu-tao-kou in the upper Fa-pieh-la Ho is rather narrow, only 20 to 50 m wide, and a gold-bearing gravel bed 1 m thick is found at a depth of 2 m. Boulders in the gravel are round, and consist of granite, gneiss and other igneous and metamorphic rocks. Boulders, 5 to 15 gr in weight, are abundant. Gold locally is concentrated to a grade of 18.0 gr per cubic yard. The P'ing-yuan Gold Mine produced 1680 kg of pure gold in 1925, the Ta-ching Gold Mine produced 4.3 kg, the Chih-ch'ing Gold Mine 23.3 kg, and the Hsiang-yeh Gold Mine 1.5 kg. (2) Ni-ch'i-ho (Hsing-an Gold Mine 興安金礦). The gold placer extends from Wu-tao-kou to the Ni-ch'i-ho Ho across the divide of the Hei-ho-ching-an-ling Shan-no. In the Hsing-an Gold Mine area, the gold-bearing gravel bed occurs at a depth of 4 to 5 m, and is distributed throughout a flood plain 1.0 km in width, which is 7 or wider than at Wu-tao-kou. (3) Hei-ho-ch'ing (Hei-ho-ch'ing Gold Mine). The gold-bearing gravel bed, distributed even in the hilly land 2 km west of the waterbed above the Ni-lan Ho, occurs 2 to 4 m below the ground surface.	WILKING, Knitar, 1935, On the marshy land in northern Hei-ho-ching-an-ling district. Unpub. rept., Geol. Inst., S. Manchuria Ry. Co. NOMAKA, Jun'ichi, 1944, A preliminary report on the Devonian brachiopods from North Manchuria. Japanese Jour. Geology and Geography, v. 39, nos. 1-4. SAITO, Rintji, compiler, 1940, Geological map of Manchuria and adjacent areas, scale 1:5,000,000. Manchurian Geol. Inst. SHIZOTA, Isao, 1935, Geology and geography along the route Hei-ho (黑河) -- Kuo-ch'ang (古長) -- Ku-ch'ang (庫車) Gold mine (古長金礦) -- Hei-ho (黑河). Unpub. rept., Geol. Inst., S. Manchuria Ry. Co. USHIMARU, Shitaro, and others, 1937, Geology and geography of northern Manchuria. Geol. Inst., S. Manchuria Ry. Co. WONG, W. H., 1928, On the placer gold along the Amur River. Jour. Mining and Metallurgy, v. 2, no. 5. YABE, H. and SUKIYAMA, T., 1942, A Lower Devonian Fauna from North Manchuria. Tokyo Imp. Acad. Proc., v. 18, no. 8.																								
	Neogene formation	Shale, sandstone, conglomerate, bentonite and lignite; thickness 10 to 60 m	The Neogene formation consists of clayey shale, soft sandstone, and unconsolidated conglomerate, intercalated with bentonite and lignite. The formation in the lower reaches of the Fa-pieh-la Ho (小興安山) consists of yellowish-brown false-bedded sandstone with pebbles in the upper part, and sandstone and conglomerate in the lower part; pebbles of the conglomerate are mainly sedimentary rocks. The formation in the U.S.S.R. may be more than 50 m thick.																										
	Neogene basalt	Doleritic augite-olivine basalt; thickness more than 100 m	Neogene basalt forms plateaus and is a dark gray to dark brown, rough, coarse-grained, holocrystalline, doleritic basalt, without visible phenocrysts. The groundmass contains many microcrystals of augite and olivine.																										
	Cretaceous andesite	Biotite andesite with agglomerate	Cretaceous andesite flows are sporadically exposed in the uppermost reaches of the Fa-pieh-la Ho. It is purplish brown basaltic biotite andesite associated with agglomerate.																										
	Cretaceous rhyolite	Rhyolite and obsidian	Cretaceous rhyolite occurs as flows consisting of rhyolite and obsidian. (1) White rhyolite near Sun-tao-kou (三島山) looks like quartzite or limestone, but under a microscope it is seen to consist of round quartz grains and decomposed feldspar with marked cleavage. (2) The rock in a hill 10 km west-northwest of Hei-ho (黑河) is blackish brown, holovine and obsidian-like, and locally contains phenocrysts of quartz and a small amount of biotite.																										
	Cretaceous(?) volcanic complex	Andesite porphyry and diorite porphyry, with breccia; thickness unknown	The Cretaceous(?) volcanic complex is a complicated assemblage of grayish brown, intermediate to basic or acidic intrusives and extrusives. (1) The rock on a hill north of Hei-shan-hou (海山后) is dark brown compact andesite porphyry containing small phenocrysts of plagioclase. (2) The rock near Sun-tao-kou-tzu (三島山) is gray diorite porphyry consisting of glass and phenocrysts of hornblende and feldspar. (3) The rock near Hei-t'ao-tzu (海套子) is grayish green chlorite andesite porphyry. (4) The rock in the valley 2 km east of Hei-shan-hou (海山后) is dark green compact hackly andesite porphyry containing microcrystals of magnetite; phenocrysts were metamorphosed into chlorite, and the groundmass is greenish due to actinolite crystals of plagioclase. It intrudes the Paleozoic formation (P). (5) The rock in a cliff west of Hei-ho is dark green, hard compact diorite porphyry dikes intruding the pre-Jurassic granite (G). The dikes strike N 25° E and dip 60° SE. The complex occurring as flows rests unconformably on the crystalline schist (Sch), the pre-Jurassic granite (G), and the Jurassic formation (J). The complex occurring as sheets intrudes the Paleozoic and the Jurassic formations which were metamorphosed by igneous intrusions. The age of the complex on the east bank of the Amur River was defined by Soviet geologists (NALLIVKIN, 1955) as the Upper Cretaceous volcanic complex.																										
	Cretaceous(?) formation	Conglomerate and arkosic sandstone; thickness unknown	The Cretaceous(?) formation rests unconformably on the Devonian formation (Dev) in the southwest corner of the map. It consists of conglomerate and arkosic sandstone.																										
	Jurassic formation	Sandstone, shale, conglomerate and coal; thickness unknown	The Jurassic formation along the Amur River consists of sandstone, shale, and conglomerate, with thin seams of low-grade coal in the south. The rocks near Man-chou-t'ung (滿洲屯) and Tu-yin Shan (吐音山) were metamorphosed into graywacke and clay slate owing to the intrusion of the Cretaceous volcanic complex.																										
MESOZOIC	Quartz porphyry	Quartz porphyry, porphyry and granite porphyry	Quartz porphyry, including porphyry and granite porphyry, are sporadically exposed in small areas as follows:																										
			<table border="1"> <thead> <tr> <th>Locality</th> <th>Lithology</th> <th>Occurrences</th> </tr> </thead> <tbody> <tr> <td>Cliff north of Wu-tao-kou (五島山)</td> <td>Grayish green rock with smoky quartz, light pinkish orthoclase, green plagioclase, and biotite showing marked oblique jointing.</td> <td>Intruded between G₂ and P.</td> </tr> <tr> <td>Hill 2 km NW of Wu-tao-kou-hsia-t'ou</td> <td>Quartz porphyry with large phenocrysts of orthoclase 2 cm in size.</td> <td>Intrudes as a stock.</td> </tr> <tr> <td>Hill 9 km NW of Wu-tao-kou-hsia-t'ou</td> <td>Quartz porphyry with large phenocrysts of orthoclase and biotite.</td> <td>Intrudes G₂.</td> </tr> <tr> <td>Near T'ou-tao-kou (頭套山)</td> <td>Consists of reddish purple glass, quartz, feldspar, and biotite.</td> <td>Intruded between G₂ and P, as a stock.</td> </tr> <tr> <td>Valley 3 km northeast of Ni-ch'i-chin-ch'ang (尼奇金礦)</td> <td>Light reddish to dark gray porphyry with orthoclase phenocrysts and compact groundmass.</td> <td>Intruded between G₂ and P.</td> </tr> <tr> <td>Lower reaches of the Ta-o-ni Ho (大興安河)</td> <td>Reddish brown granite porphyry, abundant in feldspar, with few quartz and colored minerals.</td> <td>Intrudes G₂.</td> </tr> <tr> <td>Valley north of Ia-erb-pin Shan (利爾賓山)</td> <td>Light gray rock consisting of large phenocrysts of orthoclase and holocrystalline fine-grained groundmass.</td> <td>Occurs between P and G₂.</td> </tr> </tbody> </table>	Locality	Lithology	Occurrences	Cliff north of Wu-tao-kou (五島山)	Grayish green rock with smoky quartz, light pinkish orthoclase, green plagioclase, and biotite showing marked oblique jointing.	Intruded between G ₂ and P.	Hill 2 km NW of Wu-tao-kou-hsia-t'ou	Quartz porphyry with large phenocrysts of orthoclase 2 cm in size.	Intrudes as a stock.	Hill 9 km NW of Wu-tao-kou-hsia-t'ou	Quartz porphyry with large phenocrysts of orthoclase and biotite.	Intrudes G ₂ .	Near T'ou-tao-kou (頭套山)	Consists of reddish purple glass, quartz, feldspar, and biotite.	Intruded between G ₂ and P, as a stock.	Valley 3 km northeast of Ni-ch'i-chin-ch'ang (尼奇金礦)	Light reddish to dark gray porphyry with orthoclase phenocrysts and compact groundmass.	Intruded between G ₂ and P.	Lower reaches of the Ta-o-ni Ho (大興安河)	Reddish brown granite porphyry, abundant in feldspar, with few quartz and colored minerals.	Intrudes G ₂ .	Valley north of Ia-erb-pin Shan (利爾賓山)	Light gray rock consisting of large phenocrysts of orthoclase and holocrystalline fine-grained groundmass.	Occurs between P and G ₂ .		
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PALEOZOIC	Diorite	Hornblende diorite	Diorite, occurring as lenticles or sheets, consists of andesine rarely associated with labradorite, hornblende, and augite, besides accessory minerals. (1) Diorite 4 km south of Hei-shih-te-chi (海世德池) intrudes the pre-Jurassic granite as a lenticle. The rock is dark gray and compact, showing a marked oblique jointing. (2) Diorite near Sun-tao-kou is dark green, hard and compact, and consists mainly of hornblende and a small amount of plagioclase. (3) Diorite on a hill south of the T'ieh-ch'i-ho (鐵齊河) occurs as a monolith in the Neogene basalt plateau. The rock is dark green, consisting of fine-grained plagioclase and a small amount of hornblende.																										
	Pre-Jurassic granite	Hornblende-biotite granite, gneissic granite and micrographic granite	Pre-Jurassic granite, associated with more or less gneissic granite, occurs as batholiths and lenticles probably intruded during the Triassic. The granite is light gray, reddish gray, or reddish green, showing a nonuniform texture. The rock consists of orthoclase, plagioclase, hornblende, biotite, and a small amount of quartz. Apatite, magnetite, titanite and rarely zircon occur as accessory minerals. The exposed granite is generally decomposed by weathering to a depth of 2 m, resulting in residual soil or arkose sand; colored minerals are metamorphosed into chlorite. The granite in the southeastern part of the map area is medium-grained hornblende-biotite granite, except for a coarse-grained part at the south of the Hei-ch'ing Ho. The granite in the western part is medium to coarse-grained, and consists of biotite, hornblende, and a small amount of quartz. The rock near the east 8 km southeast of Wu-tao-kou is light greenish gray hornblende granite, consisting mainly of orthoclase and hornblende. The rock near Lo-t'ao-p'o-tzu is a micrographic granite.																										
	Granite gneiss	Biotite granite gneiss, metagneiss and paragneiss	Granite gneiss, occasionally associated with metagneiss or paragneiss, is exposed along the Amur River. It may be a marginal facies of the pre-Jurassic granite. Near Chiu-tu-ho-tzu (秋圖河子) and on the west bank of the Amur River, it is a fine-grained biotite granite gneiss showing a marked schistosity. The rock in a cliff west of Hei-ho is a brownish green medium-grained orthogneiss, locally accompanied by megacrysts containing large crystals of orthoclase. The schistosity strikes NE, parallel or oblique to the contact of the granite. The rock near Hei-ho-ch'ing (海河) grades into injection granite. The rock near Ho-t'ao-kou (浩套山) is green coarse-grained paragneiss, consisting of quartz, feldspar and chlorite.																										
	Paleozoic formation	Clay slate, graywacke, shale and sandstone; thickness unknown	The Paleozoic formation is exposed in large areas along the Fa-pieh-la Ho and the Hsiang-pieh-la Ho (興安山). It consists of clay slate and graywacke, locally associated with shale and sandstone where the igneous intrusion was not severe. The clay slate predominates throughout the formation. It is a dark black slate, showing a marked jointing in the hill 4 km east of Hei-shan-hou. The graywacke or sandstone is exposed on the eastern bank of the Ia-erb-pin Ho and in a hill north of Wu-tao-kou-hsia-t'ou (海套子). The sandstone on the river bank is black to dark gray, fine- to coarse-grained, consisting of quartz and feldspar. It strikes N 15° - 20° W, dipping 10° NE. The formation generally strikes N, and is intricately folded. Although no fossils have been found, the formation may be lithologically correlated with the Upper Paleozoic, probably Permian, formation of North Manchuria.																										
	Middle(?) Paleozoic formation	Crystalline limestone, marl, sandstone, shale and phyllite; thickness unknown	The Middle (?) Paleozoic formation is exposed along the Amur River north of Man-chou-t'ung. It consists of crystalline limestone, marl, sandstone, shale, and phyllite.																										
	Devonian formation	Shale, limestone, phyllitic schist, conglomerate, sandstone and marl; thickness more than 130 m	The Devonian formation is exposed between the Ni-ch'i-ho and the T'ieh-li-ch'i Ho. It can be divided into Middle (Eifelian) and Lower (Coblenzian). The Middle Devonian formation occurs in the hill east of Han-ta-ch'i, 4 km northeast of Ho-lung-san (興龍山), with the stratigraphic succession in descending order as follows: (a) purple shale interbedded with thin layers of limestone and chocolate colored phyllitic slate, (b) black limestone interbedded with quartzite, (c) green limestone yielding many brachiopod fossils, (d) conglomerate. The formation yields the following fossils identified by KOBAYASHI and NOMAKA (1942): <i>Spirifer speciosus</i> , <i>Spirifer cf. striatus</i> , <i>Spirifer tomkinsensis</i> , <i>Strophomenid sp.</i> , <i>Rhynchonella sp.</i> , <i>Favosites sp.</i> , <i>Strophomena (Strophomena) sp.</i> , <i>Strophomena cf. sinensis</i> , <i>Strophomena sp. undet.</i> , and <i>Alcyon Resurgens</i> Sowerby. The formation strikes N 10° E and dips 20° SE. The Lower Devonian formation was reported in 1941 when fossils were collected from the black sandy shale obtained by dredging for gold near Sun-tao-ch'i (三島山) and were identified by H. YABE, T. SUKIYAMA and M. NODA in 1942 as follows: <i>Tubulatia (Pleurodictyum) nodata</i> Yabe and Sugiura, <i>Pleurodictum</i> (<i>Syringonella</i>) sp., <i>Brachiopoda (Strophomena) cf. sedgwicki</i> D'Archiac and De Verneuil. On the basis of the fossils the formation was defined as Lower Eifelian (Coblenzian) in age. Other fossils known are shown in the following table. The formation in the hill east of Chiu-shih station is unconformably overlain by a Cretaceous(?) conglomerate and rests on green to reddish green siliceous slate of unknown age. The stratigraphic sequence in descending order follows: (1) green sandstone (20 m), (2) conglomerate with granite pebbles (2 m), green calcareous sandy rock yielding many fossils (20 m), (3) platy greenish gray sandstone (50 m), (4) marl with rare fossils (10 m), and (5) green calcareous sandstone (20 m). The fossils were identified by NOMAKA (1944) as follows: <i>Brachiopoda</i> , such as <i>Plectrospirifer cf. grandis</i> Yabe and Sugiura, <i>Rhynchonella parallelipipeda</i> (Bron.) var., <i>Goniatitella sp.</i> , <i>Schizophoria</i> sp., and some species belonging to <i>Lamellibranchia</i> as well as <i>Gastropoda</i> and <i>Tribolites</i> . The formation strikes N 60° W to NE, dips steeply to the south, and is intruded by many dikes.																										
	Silurian formation	Limestone, sandstone, marl, shale and phyllite; thickness unknown	The Silurian formation, consisting of limestone, sandstone, marl, shale and phyllite, is exposed in the U.S.S.R., along the Amur River. Available data are very few.																										
	Crystalline schist	Chlorite schist and chlorite-hornblende-biotite schist	The crystalline schist, probably of Precambrian age, is exposed in the following two places: (1) The rock between the Amur River and the Ia-erb-pin Ho is a spotted chlorite-hornblende-biotite schist showing a marked schistosity. The rock is affected by the intrusion of the Mesozoic volcanic complex. (2) The rock near Sun-tao-kou consists of chlorite schist.																										
		(Column not drawn to scale)																											

COAL
The Jurassic formation along the lower reaches of the Amur River is interbedded with thin coal seams: (1) A coal seam exposed on the west bank of the Amur River, 33 km north of Hei-ho, is 0.3 to 0.7 m thick, and extends to the north for a distance of 100 m. The coal was formerly worked unsuccessfully owing to the value of the Amur River and the inferior quality. (2) The quality of the coal seams near Ta-o-ch'ing-1-erh (大興安河) and Ho-t'ao-kou is poor.

LIMESTONE
(1) Paleozoic crystalline limestone is calcined for lime at Shih-hui-yao (石灰窑), north of Man-chou-t'ung, along the Amur River. (2) Devonian limestone, 20 m thick, near Chiu-shih station, (not shown on map), near the outcrop of M, may be useful for producing lime and cement.