

GEOLOGIC COLUMN AND UNIT DESCRIPTIONS

AGE	ROCK UNIT	LITHOLOGY: THICKNESS WHERE KNOWN	REMARKS	ECONOMIC VALUE															
QUATERNARY	Alluvium	Sand, gravel, and clay. Thickness less than 10 meters	Alluvium, with a maximum thickness of 10 m, is composed of sand, gravel, and clay, and generally covers the remains of low terraces and flood plains.	During the period of 1938 to 1940, Quaternary placer gold deposits in the vicinity of Tung-hsing-chen district on the Hun-chun Ho (erroneously spelled Kun-chun Ho or Hsu-chun Ho on the map) were test-drilled by Japanese gold mining companies, but gold dredging did not commence on account of the political situation at that time.															
	Diluvium	Sand, gravel, and clay, contains placer gold. Thickness less than 20 m	Pleistocene deposits, about 20 m thick at most, consist of coarse sand, gravel, and clay of fluvial origin. The deposits usually cover the remains of higher terraces. The basal gravel bed is generally auriferous and has occasionally been worked for placer gold.																
TERTIARY	Neogene basalt	Flows of basalt, with thickness varying between several meters to 400 m	Neogene basalt flows vary in thickness from several meters to 400 m and may have erupted at different times during the period from Miocene to Pleistocene over the old plateaus. The lava plateau on the Russo-Manchurian border covers a broad area extending from Tung-ning (图宁) to as far south as Tung-hsing-chen (兴城), and the so-called "Wai-an-chang" (怀安常) lava plateau covers the mountains of Ma-leng-to-chi Ling (马愣托奇岭) in the northwestern part of the map area. As these lava plateaus are generally not yet eroded to a stage of topographic maturity, streams and rivers in these lava districts have not cut down into the bed rock. Basalt of the Russo-Manchurian borderland is generally grayish to black, compact, non-porphyrific, and contains little olivine. Porous or amygdaloidal lavas also occur. Columnar jointing, and jointing showing columnar and platy characteristics combined are common. Mineralogically, these plateau lavas are divided into the monochlase pyroxene-doleritic basalt and the augite basalt, of which the latter is predominant. The plateau basalt of Ma-leng-to-chi Ling is generally a titan-augite-olivine-doleritic basalt. It is black, holocrystalline, and locally is aphanitic.																
	Neogene beds (Tumentzu formation)	Tuff, sandy shale, clay, sandstone, and conglomerate. Approximate thickness 130 m	Neogene beds (T <sub>1</sub> ), or the so-called Tumentzu formation of the Tung-hsing-chen district, attains a thickness of 130 m. Its stratigraphic sequence in descending order is as follows: (c) ash-colored tuff; (d) loose sandy shale, 100 m; (e) diatomaceous sandy clay, 1.5-4 m, containing fossil plants; (b) pebbly sandstone, 10 m; and (a) basal conglomerate, 2 m. Diatom species are mostly Helosira. Fossil plants include species of <i>Taxus</i> , <i>Quercus</i> , <i>Fagus</i> , <i>Corylus</i> , and <i>Ulmus</i> , and pollen of <i>Ericaceae</i> is also abundant. Tumentzu formation overlies the Paleogene coal-bearing beds, probably unconformably. Tumentzu formation is considered to be Miocene-Pliocene.	The basal conglomerate of Tumentzu formation, containing placer gold deposits, occurs mainly in the hills rising on the west side of the Tung-hsing-chen plain. Until 1942 several Chinese contractors had been working the placer gold by a systematic ground sluicing method and by driving underground tunnels.															
	Paleogene beds	Sandstone, tuff, shale, conglomerate, and coal. Thickness not known	In the Tung-hsing-chen district in the center of the map area, outcrops of Paleogene beds (T <sub>2</sub> ) are limited as they are covered by the Tumentzu formation. The thickness of coal seams is not known. The coal-bearing beds near Tu-men-tzu (图们) are composed of sandstone interstratified with tuffaceous sandstone, and containing thin layers of tuff and shale; three seams of low-grade lignite occur in the strata which dip gently, about 10°. The beds can be correlated to the Oligocene Hunchun Formation in the lower reaches of Hun-chun Ho (see Hun-chun sheet, NK 52-5). In Lo-tzu-kou (洛图沟) district, a formation composed of sandstone and conglomerate, with a thickness of 500 m, was reported to overlie the Lower Cretaceous formation with slight unconformity; this is also considered as Paleogene although it lacks diagnostic fossils. In the coastal zone of Amursky Bay in the Soviet Union, widely distributed Paleogene beds, which can be correlated to the Forstet series, underlie the Neogene basalt.	Lignite occurs in the Paleogene beds but has not been worked for some years because of their small economic value.															
	Paleogene basalt	Flows of andesitic basalt	Paleogene basalt is constituted mainly of flows of andesitic basalt covering the hills west of Lo-tzu-kou basin. It is considered to be a non-plagioclase-forming basalt. It may have been erupted over a mountain block which survived Miocene unroofing. Basalt of this type is eroded to the stage of topographic maturity in contrast to the Neogene plateau-forming basalt. At Lo-tzu-kou, Paleogene basalt overlies the Lower Cretaceous Lotzouk formation unconformably. The rock is dark-colored, compact, and aphanitic. Very rarely it shows microphenocrysts of plagioclase; the groundmass of granitic texture consists mainly of lath-shaped labradorite with some augite and much glass. The age of its eruption is probably pre-Miocene.																
MESOZOIC	"Tuffaceous Nikan"	Tuff, agglomerate, sandstone, conglomerate, and diabase. Thickness about 500 m	In the Upper Sui-fun (Sui-fen in Chinese territory) coal field in Soviet, the Upper Cretaceous formation is called "Tuffaceous Nikan". It is about 500 m thick. According to KOZLOFF (1924), the sequence of the formation in descending order is as follows: (d) variegated tuff containing the plant fossils <i>Podocarpites</i> and <i>Equisetites</i> ; (b) diabase flow and its volcanic agglomerate; and (a) tuffaceous sandstone and conglomerate.																
	Lotzouk formation	Sandstone, shale, conglomerate, and oil shale. Thickness more than 400 m	The Lower Cretaceous in the map area is represented by Lotzouk formation which attains a thickness more than 400 m near Lo-tzu-kou. In descending order the formation can be divided as follows: (C) upper part, 200 m thick, composed of 2) tuffaceous sandstone and shale, and 1) light yellowish gray sandy tuff, tuffaceous sandstone and shale with several layers of oil shale; (B) middle part, 50 m thick, composed of 2) tuffaceous sandstone and shale with marl lenses and several layers of oil shale, and 1) tuff; (A) lower part, 100 m thick, composed of tuffaceous sandstone and sandy shale with a few layers of oil shale. Fossils contained in the Lotzouk formation are, <i>Cladophrasites exiliformis</i> (Geyler), <i>Cladophrasites</i> sp. 4, from the upper part; <i>Ephedrites kantonsis</i> Matsunaga, <i>Cladophrasites</i> sp. 4, <i>Platocladus</i> ( <i>Cladophrasites</i> ) <i>curvifolius</i> (Dunbar), <i>Cladophrasites</i> <i>trigonatus</i> (Geyler), <i>Pityophyllum</i> sp., <i>Sphenopteris</i> sp., from the middle part; and <i>Manchurichthys unatoko</i> Sakto, <i>Ephedrites kantonsis</i> Kobayashi and Kido, <i>Brachyphyllum</i> sp., <i>Pityites iwaiana</i> Oishi, and <i>Sphenopteridium sternerbergianum</i> (Dunbar), from the upper part.	In 1938, the South Manchuria Railway Company conducted various studies, including test-drilling, on the Lo-tzu-kou oil shale. As a result, probable reserves of 500 x 10 <sup>4</sup> tons for an area of 1.5 x 1 km were estimated at Suo-lao-kou (苏老扣) near Lo-tzu-kou. The horizon of the oil shale proved to be a mixture of aspropellic and land plant bituminous material. The oil shale is higher in grade than the Fu-shun oil shale of South Manchuria, but not workable due to small reserves. An average yield is 10% crude oil.															
	Tungning series (China) "Arkose Nikan" (USSR)	Sandstone, shale, conglomerate, coal, and oil shale. Thickness about 400 m	The Upper Jurassic is represented by the coal measure in Fo-yeh-kou (扶余) district in Tung-ning basin, and its eastern extension beyond the Russo-Manchurian border is the Upper Sui-fun coal field of the Soviet Union. The formation near Fo-yeh-kou dips very gently and consists, in descending order, of: (c) arkose sandstone, (b) sandstone and shale with coal and oil shale, and (a) basal conglomerate. The total thickness is not known. Fossils from the strata at Tu-men-tzu (图们), south of Fo-yeh-kou, include <i>Sphenopteris</i> ( <i>Quoyosia</i> ) <i>elongata</i> (Geyler), <i>Wissowia</i> <i>perles</i> Gislén, <i>Cyrtodolops</i> <i>toposa</i> Oishi, <i>Pterophyllum angustum</i> (Straun), <i>Pterophyllum</i> sp., the coal-bearing beds of Chu-to-kou (图图) coal field near Lao-hai-shan (老海山) and Chen-chang-kou (陈常扣) coal field (covering Shang-chien-chang-kou (商前常扣) and Hsu-chien-chang-kou (许前常扣) coal fields) can also be classified as the Upper Jurassic. These coal measures consist mainly of sandstone intercalated with low-grade bituminous coal and oil shale, and gently dip to the west, but their structure and sequence have not been confirmed. According to KOZLOFF (1924), the sequence of the Upper Jurassic beds in the Upper Sui-fun coal field on the Soviet border is as follows, in descending order: Arkose sandstone formation (375-400 m thick) (3) Coal-bearing sandstone and shale (100-125 m) (2) Soft sandstone, marked with false bedding (125 m) (1) Conglomerate with bands of soft sandstone (150 m) Basal conglomerate formation (thickness not given) (Information on the fossils reported by KOZLOFF from the arkose sandstone is given on the Sui-fen-ho sheet (NK 52-12).)	Coal-measures in China generally contain 3 or 4 coal seams. The coal-producing area in the Tung-ning district is named Tung-ning coal field, and the corresponding part in Soviet Union is called Upper Sui-fun coal field. The Tung-ning coal field has been worked intermittently since 1941 at such villages as Fo-yeh-kou, Hsu-cheng-tan (许成坦) of Faw-she-kou, and Lao-hai-shan. The thickness of the working seam is 0.5-1.0 m at Fo-yeh-kou, and 1.0 m at Lao-hai-shan. Result of analyses, in percent, were as follows: <table border="1"> <tr> <td></td> <td>H<sub>2</sub>O</td> <td>Ash</td> <td>V.M.</td> <td>F.C.</td> </tr> <tr> <td>Coal from Fo-yeh-kou</td> <td>2.52</td> <td>18.52</td> <td>47.21</td> <td>31.25</td> </tr> <tr> <td>Coal from Lao-hai-shan</td> <td>6.06</td> <td>12.13</td> <td>52.70</td> <td>29.11</td> </tr> </table> The coal is bituminous coal of very low grade. Possible coal reserves were estimated as 20 million tons for Lao-hai-shan and 2.3 million tons for Fo-yeh-kou. Borings tests were not made for the coal measures. No data is available on the Upper Sui-fun coal field.		H <sub>2</sub> O	Ash	V.M.	F.C.	Coal from Fo-yeh-kou	2.52	18.52	47.21	31.25	Coal from Lao-hai-shan	6.06	12.13	52.70	29.11
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Lower volcanic complex	Trachyandesite, andesite, dacite, and pyroclastic rocks. Thickness about 300 m	The lower volcanic complex consists of lava flows of aphanitic andesite, trachyandesite, dacite, plagioclase rhyolite and their pyroclastic rocks. The thickness is at least 300 m. The rocks of the complex are generally modified by secondary changes, and are called "porphyrites". The volcanic complex has a broad distribution from the north and through the central part to the southwestern part of the map area. On the west side it overlies granite (g <sub>2</sub> ), quartz porphyry (qp), and the Tounan formation (Tn); on the east side it overlies Neogene basalt (N <sub>2</sub> ). Eruption of these volcanic rocks may have been in the Lower Jurassic.																	
Mongugai series	Sandstone, shale, conglomerate, and coal. Thickness about 1,700 m	Mongugai series (named by M. K. ELIASCHENITCH) is about 1,700 m thick, and is distributed on the north side of the Mangugai (Mongugai) River which empties into Amursky Bay. The series is divided into the upper part and the lower part. The upper part consists of arkose sandstone, shale, and conglomerate (fresh and crinoid stems) deposited intercalated with several productive coal seams. It overlies the Upper Paleozoic rocks (P <sub>2</sub> ) and granite (g <sub>2</sub> ) unconformably, and its geologic age is believed to be between Upper Triassic and Rhaetian.	Mongugai series northeast of Barabash, USSR, is reported to contain 8 seams of coal, each measuring about 1 m thick, of which 5 seams are workable. The lowest 3 seams were being worked by the Mangugai (Mongugai) Coal Mine in 1917 when KOTERA JIMBO visited there. The coal generally contains many partings, and the coal measure shows a general dip 15° southeast. A proximate analysis of coal revealed 56.7% fixed carbon, 10.5% volatile matter, and 31.25% ash, and the coal ranks close to semi-anthracite.																
PALEOZOIC	Quartz porphyry	Quartz porphyry and granite porphyry	Quartz porphyry is a marginal modification of the granite (g <sub>2</sub> ); there is a minor amount of granite porphyry. It is predominant in Tu-huang-tau (图黄套) district, southeast of Hsu-shao-pu (许少铺). The rock is overlain by the Mesozoic lower volcanic complex (M <sub>2</sub> ) and shows intrusive contact with the rock of Upper Paleozoic (P <sub>2</sub> ).																
	Diorite	Diorite and granodiorite	Diorite is mainly quartz diorite and is widely distributed south of the Fo-yeh-kou coal field; its eastern extensions are found in the Soviet area underlying basalt lava. Diorite on the Russo-Manchurian border has been considered to form the bed rock of the Upper Jurassic coal fields, but in the Soviet Upper Sui-fun coal field the presence of a granodiorite laccolith in the coal measure was reported by KOZLOFF. The diorite might have a magmatic genetic relationship to the Mesozoic lower volcanic complex (M <sub>2</sub> ), except for a few younger bodies.																
	Granite	Biotite granite and biotite-hornblende granite	Granite of pre-Jurassic system is mainly biotite granite and hornblende granite. It is intruded into the Upper Paleozoic (P <sub>2</sub> ), and the effect of contact metamorphism is observed in many localities. The age of the granite intrusion is considered as Triassic.																
AGE UNKNOWN	Touman formation	Graywacke, phyllite, slate, shale, conglomerate hornfels, limestone, schist, and gneiss. Thickness not known.	The Upper Paleozoic Touman formation affected by contact metamorphism, as observed in many places. It consists of graywacke, slate, conglomerate hornfels, and crystalline limestone. Spotted chlorite schist, chlorite-mica schist, and metagraywacke are occasionally found in the strongly metamorphosed parts. A marine Permian formation was reported in the Soviet area 20 km upstream from the mouth of the Mangugai River. The bed rock of the Upper Sui-fun coal field was also reported as Upper Paleozoic. However, in the Geologic Map of the USSR (1924) all the pre-Mongugai formations of the western coastal range of Amursky Bay are mapped as Triassic. The pre-Mongugai sediments of the Soviet Amursky Bay area have been assigned to Upper Paleozoic on this map, although information is poor.																
	Crystalline schist	Schist and crystalline limestone, with injection gneiss. Thickness not known.	Crystalline schist distributed east of the Lo-tzu-kou basin, in the northwestern part of the map area, extends in a northeasterly direction. The rock consists mainly of garnetiferous albite-mica schist with a schistosity in a north-northeast direction. The rock is wholly modified by regional metamorphism. It is uncertain whether the rock belongs to the schists of the metamorphosed Upper Paleozoic or to the Precambrian schists.																

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