Metallic Deposits in Manchuria

Tsutomu Ogura

1. History of Research on Ore Deposits

Japanese geologists had surveyed and studied ore deposits in Manchuria without distinguishing between metals and nonmetals. As early as the Sino-Japanese (1894–1895) and Russo-Japanese wars (1904–1905), mining investigations had been undertaken; afterward, research by the Geological Survey of the South Manchuria Railway Co., the Ryojun College of Engineering established in 1924, and universities and other organizations in Japan was carried out. After the establishment of Manchoukuo in 1932, government officials and company engineers took over these tasks.

According to tradition, mining operations in Manchuria began in the Kokuli age, *ca*. 950, but there is no direct evidence, such as mining ruins, for such a date. In some cases, there is comparatively recent evidence, the age of which can be estimated, but in very few instances do operations seem to have continued for a lengthy period.

The discovery and exploitation of mineral resources is dependent to a great degree on the human element and natural conditions such as climate and topography. In this connection it should be remembered that Manchuria was a thinly populated land with great areas unexplored and unpopulated, and that the inhabitants were unfamiliar with mining methods. Therefore, the development of mining could not be expected in difficult-to-reach districts. But the climatic conditions in Manchuria are favorable to the discovery of deposits. Generally the soil mantle is thin and bedrock crops out on the mountainland. Consequently, outcrops of deposits are easy to discover, and it sometimes happens that important ore bodies lie at relatively shallow depths.

After the establishment of Manchoukuo in 1932, research on Manchurian mineral resources and geology progressed, materials on ore deposits increased, and abandoned and newly discovered deposits were actively opened up. At the end of the war, there were more than 100 metal mines distributed all over Manchuria. Most of them were in southeastern and southwestern Manchuria; mines were rarely found in the central plain or in the northern mountainland and plateau.

2. Topography and Geology of Manchuria

Topographically and geologically, Manchuria may be conveniently divided into four regions:

Southeast mountainland	Liao-tung, Chi-lin, An-tung, Chien-tao districts.
Central plain	Liao-ho, Nen-chiang, Sun-hua-chiang districts.
Southwest mountainland	Chin-chou, Je-ho districts.
North mountainland and plateau	Ta-hsing-an-ling Mts., Hsiao-hsing-an-ling Mts., Hai-la-erh district.

(1) The southeast mountainland includes a wide area to the southeast of a line which may be drawn from southwestern Liao-tung to Fu-yuan in the lower reaches of the Sung-hua-chiang, through Mukden, Hsin-ching, and Harbin. On the southeast it borders the northwestern region of Korea and the Soviet coastal province, taking a fusiform shape elongated in a NE-SW direction. Liao-tung, Chang-pai, and Wan-ta mountains make a backbone, from northeast to southwest, and the Saha-ling and Lao-chang-kuan-sui-ling mountains lie parallel to these ranges. These principal ranges tower over 1,000 m above sea level and their features are deeply incised.

As to the distribution of geologic formations in this mountainland, the Archean and Proterozoic formations are developed chiefly in the Liao-tung Peninsula, the Lower Paleozoic formation occupies scattered areas in Liao-tung and the vicinity of the Tai-tzu-ho River, and the Upper Paleozoic is developed in association with the Lower Paleozoic and also in the Chilin and Tung-an districts. The Mesozoic formation exists chiefly on the northwestern and southeastern borders, and the Tertiary along the northwestern border or outer rim of the Mesozoic. Igneous rocks are granite, gneissose granite and basalt, occupying over two-thirds of the region; there is also a small quantity of basic intrusive rocks. These formations stretch northeast to southwest, being parallel to the outline of the region, with a zonal distribution.

The principal deposits of the region, gold, silver, lead, zinc, and copper, and minor deposits of tungsten, antimony, and chromium are genetically related to the igneous activities of the early Mesozoic age. Such bedded deposits as iron, aluminum, magnesium, and pyrite are characterized by their association with the Proterozoic to Paleozoic formations.

(2) The central plain occupies a wide area 1,300 km N-S and 400 km E-W in the Manchurian plain, covering the drainage basins of the Liao-ho, the Nen-chiang and the Sung-hua-chiang. It has altitudes of 40 m above sea level in the southern part near Hsin-min-tun, 300 m in the northern end near Mo-erh-ken and 300 m at the highest point in the central part near the Hei-Liao divide.

This region consists essentially of Quaternary sediments, and notable mineral resources are not known.

(3) The southwestern mountainland includes Chin-chou and Jehol districts. The highland mountain ranges parallel each other in a NE-SW direction. There is a gradual change in elevation from the northwestern part, which is more than 1,000 m above sea level, down toward the southeast which is 300 m above sea level.

In this region the Archean formation principally occupies the central part, the Lower Paleozoic the southeastern, and the Mesozoic the central and southeastern parts. Granite is developed in places, and basalt in a wide area of the northwestern part. These formations are parallel to the NE-SW orientation of the southeastern mountainland. Principal metallic deposits of this region are gold, silver, lead, zinc, manganese, iron, tungsten and mercury ores. These deposits are genetically related to the igneous activities of the Mesozoic age.

(4) The north mountainland and plateau include the Hsiao-hsing-an-ling, Ta-hsing-an-ling mountains and the Hai-la-erh plateau. The Hsiao-hsing-an-ling mountains stretch from northwest to southeast and attain an altitude of 1,400 m above sea level, the Ta-hsing-an-ling mountains run from NNE to SSW and have a maximum altitude of 1,700 m. The Hai-la-erh plateau has an average altitude of 550 m, with much barren area.

The region is primarily occupied by granite; Lower and Upper Paleozoic and Mesozoic formations are distributed in an east-west direction and neovolcanic rocks are rare. The plateau district is covered mostly by desert deposits. Mineral resources are generally poor, and metallic deposits are placer gold and smaller amounts of copper and lead ores.

3. Formation of Ore Deposits and Their Age

Metallic deposits in Manchuria include gold, silver, lead, zinc, iron, copper, and manganese (magnesium and aluminum) as well as tungsten, pyrite, mercury, molybdenum, chromium, uranium, niobium, and tantalum ores. These deposits may be classified on the basis of igneous and sedimentary origin. It is a significant fact that in Manchuria iron, placer gold, manganese, and pyrite deposits of sedimentary origin and iron deposits of dynamometamorphic origin are developed on a large scale, whereas in Japan metallic deposits of igneous origin are by far superior to those of sedimentary origin. Deposits may also be classified on the basis of the mode of occurrence; deposits bedded in stratified rocks and metallic deposits are genetically related to igneous rocks.

Concerning the bedded deposits, the geological age, kind of ore, and area of occurrence of the bedded deposits are shown as follows.

Geological age		Kind of ore	Area
Archean			
Proterozoic			
	Liaoho system	Banded iron ore	SE mountainland .... An-shan
		Magnesite	SE mountainland .... Ta-shih-chiao
		Iron ore	SE mountainland .... Ta-li-tzu, Chi-tao-kou
	Sinian system	Iron ore	SE mountainland .... Lao-ling, Hsu-chia-tun
		Manganese ore	SW mountainland .... Wa-fang-tzu
Lower Paleozoic			
Upper Paleozoic		Iron ore	SE mountainland .... Niu-hsin-tai
		Pyrite	SE mountainland .... Pen-hsi-hu, Yen-tai
		Aluminous shale	SE mountainland .... Pen-hsi-hu, Yen-tai, Niu-hsin-tai, Hsiao-shih
Mesozoic			
Cenozoic		Placer gold	All regions

Igneous activity may be divided into six periods: 1. pre-Paleozoic (granite family), 2. Paleozoic (ultrabasic rock), 3. Early Mesozoic (granite, diorite, granite-porphyry, pegmatite), 4. Jurassic (intermediate rock), 5. Late Mesozoic (granite, diorite, granite-porphyry, quartz-porphyry, porphyrite, trachyte, andesite), and 6. Tertiary to Recent (alkali trachyte, basalt). Of these the activities of the Early and Late Mesozoic periods were most important for the formation of ore deposits.

Principal metallic deposits having direct and indirect genetic relations to igneous activity are as follows:

Age	Kind of rock	Area	Kind of ore
Early Mesozoic	Granite, granite-porphyry	SE mountainland	Lead, zinc, copper, molybdenum, tungsten, gold, antimony

	Granite, granite-porphyry	sw mountainland	Gold
	Pegmatite	SE and SW mountainlands	Uranium, niobium, tantalum
	Serpentine	sw mountainland	Chromite
Mesozoic	Gabbro	sw mountainland	Vanadium-iron ore
	Andesite	sw mountainland	Silver, lead
Late Mesozoic	Granite	sw mountainland	Gold, manganese, mercury, silver, zinc, copper, iron, tungsten, molybdenum

In view of these facts, we know that the principal sedimentary deposits in Manchuria, were formed in the Paleozoic or earlier that the origin of igneous metallic deposits, irrespective of the kind of ore, is related to early Mesozoic igneous activity in the southeastern area, and that the formation of deposits in the southwest had an intimate relation to the igneous activity associated with the so-called Yenshan crustal movement in the early to late Mesozoic age.

4. Kinds and Classification of Ore Deposits

Metallic deposits in Manchuria do not show much variety; there are about ten workable deposits: gold, silver, lead, zinc, iron, copper, manganese, pyrite, tungsten, and molybdenum. Minor ores of mercury, antimony, chromium and uranium were mined to some extent. Aluminum and magnesium ores are not considered in this review.

The ores may be classified into the following types of deposits:

Type of deposit	Kind of ore
Magmatic segregation deposits	Vanadium-iron ore, chromite
Pegmatite deposits	Uranium, niobium, tantalum
Contact-metamorphic deposits	Gold, silver, lead, zinc, iron, copper, manganese, molybdenum
Fissure fillings and metasomatic deposits	Gold, silver, lead, zinc, copper, iron, manganese, pyrite, tungsten, molybdenum, antimony, mercury
Impregnation	Copper, pyrite, molybdenum
Sedimentary deposits	Iron, manganese, pyrite, aluminum
Placer	Gold
Dynamometamorphic deposits	Iron