Jour. Fac. Sci., Hokkaido Univ., Ser. IV,
vol. 17, no. 4, Aug., 1977, pp.695-708.

METALLOGENIC PROVINCE OF HOKKAIDO

by

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(with 1 Table and 5 Figures)

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Abstract

In Hokkaido, various kinds of metallic ore deposit formed in different epochs are known, e.g., strata-bound type manganese ore deposits, replacement type magnetite deposits are observed in the Paleozoic System in West Hokkaido. Kieslager type copper ore deposits, Sudbury type nickeliferous pyrrhotite deposits, podi-form chromite deposits and a kind of vein type mercury ore deposits are found in the Mesozoic System of the Central Axial Zone of Hokkaido. Besides, gold, silver, copper, lead, zinc, manganese and mercury ore deposits of fissure filling type of Miocene period are observed closely related to the "Green Tuff Volcanism" in West and East Hokkaido. Sulphur, iron-sulphide and limonite deposits of composite type of late Neogene Tertiary to Quaternary periods spread over the island.

In this paper, the metallic mineral deposits in Hokkaido are briefly arranged from the view point of metallogenic province on the basis of the classified four mineralization epochs. Finally, some newly obtained knowledges on metallogeny of the island are also reported.

Introduction

About ten years have passed since the book "Metallic and Non-Metallic Mineral Deposits of Hokkaido" (1967) was published. During this period, various studies on mineralization of Hokkaido have been carried out and many new informations have been accumulated. The newly obtained knowledges on the metallogeny of Hokkaido are outlined in this paper.

It is well known that the peculiar topography of the island reflects three different geotectonic units. The basement of the Oshima Peninsula, West Hokkaido, is geotectonically regarded as the northern end of the Kitakami mountains which construct the Honshu Arc. It is composed of a thick geosynclinal pile of late Paleozoic to early Mesozoic periods. Characteristic features of volcanism and mineralization in the Kitakami mountains, northern Honshu, are also quite common to those in the basement of the Oshima Peninsula. For example, strata-bound type manganese ore deposits, one of the representative ore deposits in the Kitakami mountains, are recognized in the basement of the Oshima Peninsula. East Hokkaido including the Shiretoko and Nemuro Peninsulas belongs to the western end of the Kuril Arc. Thus the former is geotectonically called "West Hokkaido" and the latter "East Hokkaido" respectively.

Another geotectonic unit distinguished from the preceding two units is recognized in the central zone of Hokkaido. This unit is called "Central Axial Zone of Hokkaido" which extends with N-S trend from the Soya Cape to the Erimo Cape. The Central Axial Zone is composed of a thick geosynclinal pile of Triassic to Cretaceous periods characterized by the presence of pelitic sediments and partially intercalated green rocks. This pile formed the Hidaka mountains through the orogenic movement of the Alpine phase. Manganese ore deposits, manganiferous hematite deposits and cupriferous iron-sulphide ore deposits perhaps related to the formation of pillow lava and diabase dyke are observed here. Podi-form chromite deposits enclosed in serpentinites, and nickeliferous pyrrhotite deposits associated with dioritic gabbros are also found in the Central Axial Zone of Hokkaido. This unique geologic unit is often called by the name of "Hokkaido Proper" due to its independence from the previously stated East and West Hokkaido.

The Alpine orogenic movement in Hokkaido formed the Hidaka mountains and also yielded new geosynclinal basins at both sides of the mountains, where enormous quantities of effusive pyroclastic materials were accumulated and a peculiar pile including green colored formations were formed. This pile was intruded by various kinds of volcanic rocks such as basalt, propylite, rhyolite etc. of early to late Miocene age. These yielded a large number of epithermal ore deposits of Au, Ag, Hg, Mn, Ba and base metals. The area characterized by the presence of preceding volcanism and mineralization is called "Green Tuff Region".

Volcanism of late Neogene Tertiary to Quaternary periods in green tuff region of Hokkaido yielded sulphur, iron-sulphide, limonite and wad deposits as post-volcanic products. Two mineralization epochs, Plio-Pleistocene and Holocene, have been distinguished for these deposits.

As above-stated, mineralization of Paleozoic to Mesozoic periods, that of Neogene Tertiary period and that of late Neogene Tertiary to Quaternary periods are overlapping together in the green tuff regions. The repeated and douplicated mineralizations make the mode of occurrence of ore deposits complicated, thus the interpretation of metallogeny of East and West Hokkaido is not simple.

In this paper, the metallogenic province of Hokkaido is interpreted on the basis of four mineralization epochs based on the newly obtained data on radiometric ages of some granitic rocks and on newly proposed models of mineralization for some ore deposits, i.e., I) Mineralization of late Paleozoic to early Tertiary period, II) Mineralization of Mesozoic to early Neogene Tertiary periods, III) Mineralization of Neogene Tertiary period and IV) Mineralization of late Neogene Tertiary to Quaternary periods. In order to distinguish the mineralized area related to each phase of mineralization, three maps of Hokkaido divided into three geotectonic units are provided in this paper. These units are a) Central Axial Zone of Hokkaido, b) West Hokkaido and c) East Hokkaido.

The metallogenic province of I phase is presented as a western block boundaried by line I, and that of II phase is presented as the area enclosed by line II. Broken lines in the area show the boundaries between subdivided geologic units called "Tokoro Belt", "Hidaka Belt" and "Kamuikotan Belt" from east to west. Two areas enclosed by line III represent the metallogenic province of Neogene Tertiary period. One occupies the Oshima Peninsula and the other occupies the northeast Hokkaido. The area enclosed by line IV is the metallogenic province of late Neogene Tertiary to Quaternary periods characterized by the presence of composite type sulphur, iron-sulphide and limonite deposits.

The present author tentatively distinguishes the type of ore deposits of Hokkaido as 1) strata-bound type and 2) vein or impregnation – replacement type. Thus the ore deposits from Hokkaido can be arranged as given in following chapter based on the four ore forming epochs (I, II, III, IV), three mineralized areas (a, b, c) and the two types of ore deposit (1 and 2).

Ore Deposits of Hokkaido put in Order of Mineralization Epochs (I, II, III, IV) with Reference to Provinces (a, b, c) and Types (1 and 2)

I Ore deposits related to the mineralization of Mesozoic to early Neogene Tertiary periods

(I-b_1) Osanru (Mn), Era (Mn), Tatehira (Mn)

(I-b_2) Okushiri (Porphyry copper type Cu), Katsuraoka (Replacement type Fe),

II Ore deposits related to the mineralization of Mesozoic to early Neogene Tertiary periods

(II-a_1) Kokuriki (Fe, Mn), Nikura (Fe, Mn), Wakasa (Mn), Kunneppu (Mn)

(II-a_2) Oshirabetsu (Sudbury type Ni), Okushibetsu (ditto), Horoman (ditto), Kamikawa (Residual type Ni), Shimokawa (Kieslager type Cu), Kuroda (ditto), Koryu (ditto), Tomuraushi (ditto), Sangoi (Mn), Sanei (Cu), Nittoh (Cr), Hatta (Cr), Nukabira (Cr), Shizunai (Sb), Chiroro (Ti), Nakatombetsu (Hg), Teshio (Hg), Shotombetsu (Hg), Horokanai (Hg), Mitsuishi (Hg), Samani (Hg)

(II-c_1) Hamanaka (Kieslager type Cu)

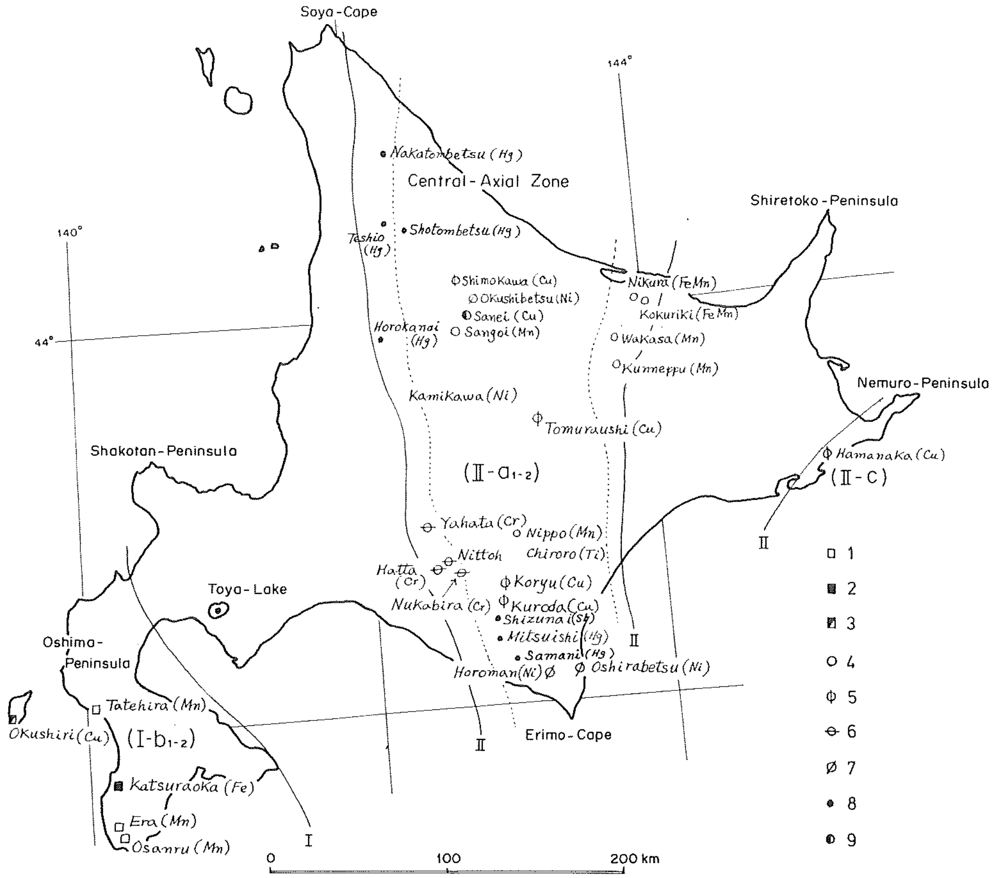

Fig. 1 Metallogenic province of Hokkaido

I Mineralization of late Paleozoic to early Tertiary periods

1 Strata-bound type ore deposits

2 Fissure filling type and impregnation-replacement type ore deposits

3 Porphyry copper type ore deposit

II Mineralization of Mesozoic to early Neogene Tertiary periods

4 Strata-bound type ore deposits

5 Kieslager type copper ore deposits

6 Podi-form chromite deposits

7 Sudbury type nickeliferous pyrrhtite deposits

8 Fissure filling type ore deposits

9 Replacement type ore deposits

III Ore deposits related to the mineralization of Neogene Tertiary period

(III-b_1) Shinmei (Fe), Pirika (Mn), Kunitomi (Cu, Pb, Zn)

(III-b_2) Matsukura (Ba), Minami-Shiraoi (Ba), Teine (Au, Ag, Te, Bi), Koryu (Au, Ag), Todoroki (Au, Ag, Mn), Chitose (Au, Ag), Toyoha (Pb, Zn, Mn, Ag, Sn), Oe (Pb, Zn, Mn), Inakuraishi (Pb, Zn, Mn), Johkoku (Pb, Zn, Mn), Yakumo (Pb, Zn, Mn), Sankei (Cu, Pb, Zn, Mn), Kamae (Cu, Pb, Zn), Momijiyama (Cu, Pb, Zn), Imagane (Cu, Pb, Zn), Suttsu (Pb, Zn, Sn), Menagawa (Cu, Pb, Zn)

(III-c_2) Kitanoo (Au), Konomai (Au), Numanoue (Au, Ag), Itomuka (Hg), Ryushoden (Hg), Kitami (Cu, Pb, Zn), Motokura (Cu, Pb, Zn), Sin-Utoro (Cu), Aizankei (Hg)

IV Sulphur, iron-sulphide, limonite deposits related to the mineralization of late Neogene Tertiary to Quaternary periods

(IV-a) Hishinaka-Tokachi, Taisetsuzan, Asahidake, Tokachidake

(IV-b) Kimobetsu, Horobetsu, Abuta, Niseko, Esan, Shohjingawa, Okushiri, Kutchan

(IV-c) Shiretoko-Iwozan, Idashubetsu, Rausu, Unabetsu, Atosa-Nupuri, Akan

Newly obtained Knowledges on the Metallogeny of Hokkaido

Mineralization of (I-b_1) group. Strata-bound type manganese dioxide deposits of the Oshima Peninsula and those of Kitakami mountains were geologically compared and the position of that of the Osanru Mine, Oshima Peninsula, is decided as a typical unmetamorphosed one which remained the original mineral assemblage. On the other hand, manganese ore deposit of Noda-Tamagawa Mine, Iwate Prefecture, Kitakami mountains, is an example of typical highly metamorphosed one related to the intrusion of Cretaceous granite. From the view point of metamorphic grade, the manganese ore deposits of Era and Tatehira Mines, Oshima Peninsula, belong to the intermediate type. Mn, Mg clinopyroxene was recently reported from Tatehira Mine by Kobayashi, Shimane University (1976)*.

Mineralization of (II-a_1) group. Green rocks including pillow lava and finally intruded ophitic diabase dyke believed to be related to the formation of strata-bound type manganiferous hematite deposits of the Tokoro mining district were chemically and petrographically investigated by Bamba (1974). He interpreted that the pillow lavas are originalily tholeiitic and yielded ferruginous quartz layer at the top of the pillow lava. Afterwards, perhaps in post-orogenic phase, ophitic diabase dykes characterized by the richness of

* Personal communucation

alkalis, intruded into the preceding pillow lavas and the overlying ferruginous quarts layer. These layers nearby the intrusives were changed to spilite and hematite ore respectively, i.e., the pillow lavas might have been albitized by ascending hydrothermal solution derived from the alkaline diabase dyke, and the ferruginous quartz layer overlying the pillow lava was contemporaneously changed to hematite ore associated with squeezed quartz and penwithite.

Mineralization of (II-a_2) group. The diabase complex, host rock of the cupriferous iron-sulphide ore deposit of the Shimokawa Mine has been investigated. i.e., the diabase has been recently classified into four facies based on the microscopic texture by Bamba (1977) as a) coarse-grained ophitic facies, b) fine-grained ophitic facies, c) variolite facies and d) aphanitic facies. The latter two facies have been considered as ultimately formed ones due to the newly found mode of occurrence.

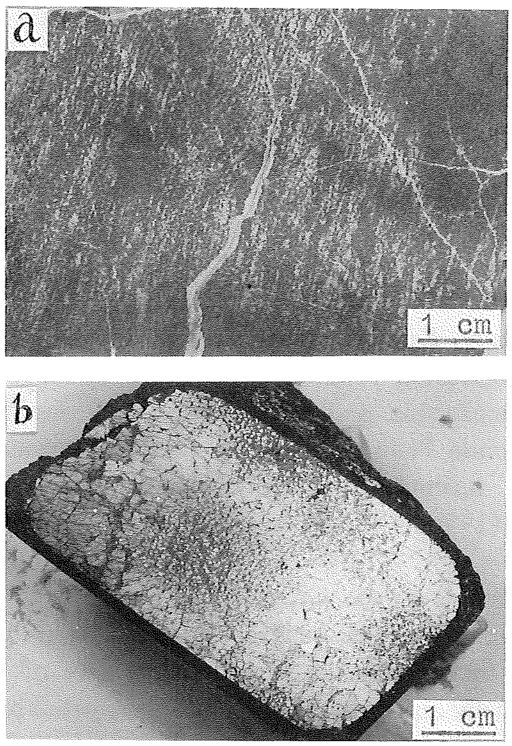

Fig. 2 Photographs illustrating two kinds of chromite ore.
a) Fine-grained disseminated ore from the Nukabira Mine showing banded structure. The flowage implies that the ore is syngenetic.
b) Compact dense ore from the Nittoh Mine enclosing the patches of disseminated ore which considered as remnants of the primary ore facies.

The aphanitic diabase intruded into the coarse-grained ophitic diabase along its cleavage has been recently observed in a gallary of the Shimokawa Mine. The variolite facies perhaps formed through the permeation of ascending liquid along the cracks of ophitic diabase is also found (Bamba 1977). It is noteworthy that the aphanitic diabase is quite equivalent in rock properties and chemistry to those of pillow formed diabase underlying the cupriferous iron-sulphide ore deposit. The chemistry of each facies of the diabase complex shows that these are wholly tholeiitic.

Chromite ores from the Nittoh and Nukabira Mines were studied by Bamba (1963, 1974) and the ore has been classified into two groups: one is disseminated ore showing flow structure by means of fine-grained subeuhedral crystals of chromite and crysotile. The other is compact dense ore forming the podi-form ore body. The former is considered that it is syngenetic origin and the latter epigenetic due to the presence of remnants of disseminated facies in the compact dense ore, which is regarded to be formed through the hydrothermal phase due to the presence of chlorite filling the space among the chromite crystals. Thus two ore forming phases can be distinguished.

The origin of stibnite and mercury ore deposits at the western piedmont of the Hidaka mountains has been recently interpreted that these may be regenerated products derived from wide-spread Hg and Sb as minor elements in geosynclinal sediments which forms the Hidaka mountains (Hunahashi, 1976). The heat engine to move these elements is considered to be originated from the migmatization and/or some successive intrusions of basic rock.

Mineralization of (III-b_2) group. In the area including Shakotan Peninsula and Toya Lake, West Hokkaido, zonal arrangement of various kinds of fissure filling type ore deposit is well known. The Toyoha Mine (Pb, Zn, Ag, Sn) is situated at the center of zoning where up-heaved massif, so-called "Shakotan Dome", is estimated. Chitose (Au, Ag), Todoroki (Au, Ag, Mn) and Teine (Au, Ag, Te, Bi) Mines are regarded as satellitic ones around the Toyoha Mine. Barite ore deposits of Matsukura and Minami-Shiraoi Mines distribute forming the outermost zone.

Filling temperatures of liquid inclusions of some ore forming minerals from the preceding mines have been investigated. The results obtained are given in Table 1 and Figure 4. As shown in Figure 4, there exist two peaks of filling temperature of liquid inclusion in both side from the axis of the Shakotan Dome, i.e. towards the north from the dome, a peak is observed at Chitose Mine and towards the south it appears at Teine Mine. The interpretation for the origin of "m" letter-form peaks of the filling temperatures of liquid inclusions of ore forming minerals around the Shakotan Dome has not been yet given.

Fig. 3 Metallogenic province of Hokkaido
III Mineralization of Neogene Tertiary period
1 Strata-bound type ore deposits
2 Fissure filling type ore deposits

Alteration halo around ore vein has been studied in Toyoha Mine, situated at the center of the Shakotan Dome (Okabe and Bamba 1976). The wall rock alterations of Todoroki Mine, at the northern shoulder of the dome, and Matsukura Mine at the northern end of the dome have recently investigated by Tomita (1977) and Sasaki (1976) respectively.

Based on the mineral assemblages, and the relative abundance of the minerals, the alteration halo around the Tajima vein, Toyoha Mine, is divided into the following four zones of altered rock facies from outer zone to inner one:

Table 1 Filling temperatures of liquid inclusions in ore forming minerals of fissure filling type hydrothermal ore deposits around the Shakotan-Dome

Mine Name	Miner. as Target	T°C	Reporter
Toyoha (Pb, Zn, Mn, Ag)			
Harima & Tajima	quartz	275-195	Fukazawa (1955)
			Kashiwagi et al (1955)
Harima & Tajima	sphalerite	255-205	Fukazawa (1955)
Tajima	qz-sph	220-140	Miyazawa et al (1971)
Tajima	qz-sph	218-132	Yajima et al (1971a)
Tajima	quartz	190-185	Watanabe
Harima	quartz	190-135	Miyazawa et al (1971)
Soya	quartz	180-110	Miyazawa et al (1971)
Soya	quartz	250-170	Shikazono (1974)
Bizen	quartz	210-130	Yajima et al (1971b)
Todoroki (Au, Ag, Mn)			
Chuetsu	quartz	150-122	Yajima et al (1971a)
Chuetsu	caleite	98-82	Yajima et al (1971a)
Teine (Au, Ag, Te, Bi)			
Takinosawa	quartz	240-180	Yajima et al (1971a)
Takinosawa	barite	178-42	Yajima et al (1971a)
Bannosawa	barite	243-241	Watanabe
Hassaku	quartz	186-160	Yajima et al (1971a)
Chitose (Au, Ag)			
Daikoku	quartz	276-247	Watanabe
Benten	quartz	230-145	Miyazawa et al (1971)
Daikoku-Nigo	quartz	260-220	Yajima et al (1971a)
Fukujin	quartz	349-176	Katsura et al (1971)
		300-200	Yajima and Ohta (1977)
Eniwa (Au, Ag)	chlorite	200-120	Yajima et al (1971a)
Koryu (Au, Ag)	quartz	180-140	Yajima et al (1971a)
Matsukura ($BaSO_4$)	barite	50	Igarashi et al (1974)
Minami-Shiraoi (Ba)	barite	50	Igarashi et al (1974)

(a) Calcite-chlorite-albite
(b) Calcite-sericite-chlorite-quartz
(c) Calcite-chlorite-sericite-quartz
(d) Quartz-sericite-pyrite

The chlorite to sericite ratio in facies (b) is higher than that in facies (c), then these two facies are distinguishable. The zones of facies (b), (c), and (d) develop in both sides of the ore vein, while the distribution of the facies (a) is regional. The rocks of four altered rock facies were chemically examined and the following results were obtained:

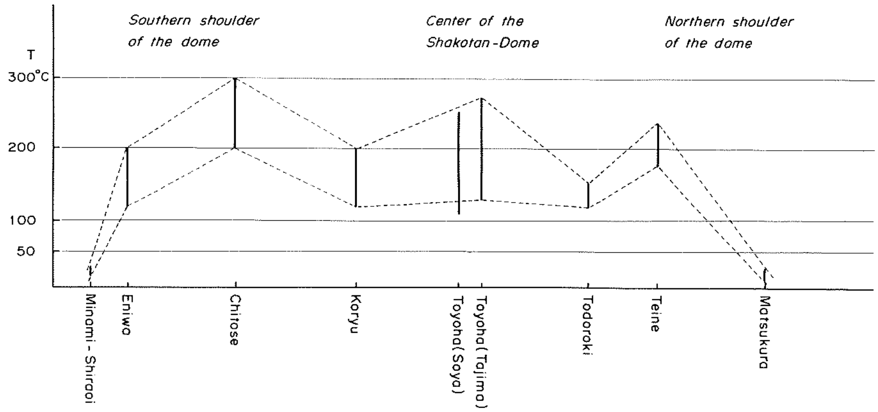

Fig. 4 "m" letter-form distribution of the filling temperatures of liquid inclusions of ore forming minerals around the Shakotan Dome.

1) Facies (a) is compositionally characterized by the presence of abundant H_2O compared with unaltered propylite.
2) In the zones of the facies (b) and (c), migration of various kinds of rock forming elements is remarkable though the original rock fabrics have been kept.
3) The zone of facies (d) is distinguishable from the preceding three zones in notable addition of SiO_2, FeS_2 and alkalis.

It seems to the author that the facies (a) alteration played a role of harbinger for the alteration around the ore vein. Facies (b) and (c) are gradational alteration zones perhaps formed by the reaction between ore forming fluid and wall rock. Facies (d) is a zone so intensely affected by the ore forming fluid that original rock fabrics were obliterated. Mixed layered mineral showing 29Å, perhaps composed of montmorillonite and chlorite, has been found at the boundary between facies (a) and (b).

It is noteworthy that Tin minerals, stannite and cassiterite, are recently found from the Izumo vein, Toyoha Mine. This newly discovery of Tin minerals by Yajima (1977) may provide an invaluable suggestions concerning the origin of the above-stated zonal arrangement of different metals related to the mineralization of III-b_2 group.

At the Todoroki Mine, the alteration halo around the Chuetsu vein were observed by Tomita (1977) and the following alteration facies from outer zone to inner one were distinguished:

a) Chlorite-albite-quartz
b) Sericite-quartz
c) Adularia-quartz

Alteration halo around the barite deposits of the Matsukura Mine has been investigated by Sasaki (1976) and following result was obtained:
a) Chlorite-celadonite-calcite-albite
b) Montmorillonite-pyrophyllite
c) Illite-kaolinite
d) Silicified facies

The massive barite ore occurs within the preceding silicified facies, and the mixed layered mineral, perhaps composed of montmorillonite and illite, have been found along the boundary between facies (b) and (c).

Mineralization of (III-c_2) group. The mineralization of this group is characterized by the deposition of a large number of mercury ore deposit at so-called "Kitami Metallogenic Province"*. As well known, profitable mercury ore deposits have not been observed at West Hokkaido in spite of the presence of preponderant green tuff volcanism. Thus it is considered that the origin of mercury ore deposit might have been related not to Green Tuff Volcanism but to be related to the Hidaka geosynclinal pile underlying the preceding Neogene Tertiary Formations. This developed idea should be supported in the relation to the mercury ore deposits of II-a_2 group found in the Hidaka geosynclinal pile. These are Shoei, Shohtombetsu, Mitsuishi, Nishicha, Samani, Nakatombetsu, Teshio and Horokanai Mines (Fig. 3).

Mineralization of (IV) group. The results recently obtained by Igarashi (1976) are quoted: Sulphur, iron-sulphide and limonite deposits formed during Plio-Pleistocene age are genetically in an intimate association and frequently form composite deposits. Some of the sedimentary type limonite deposits lacking in sulphur or iron-sulphide ore, and some of the sulphur ore deposits lacking in limonite ore were interpreted as varieties of the composite type deposit, judging from the characteristics of wall rock alteration.

Wad deposits occasionally associated with sulphur ore deposits of Holocene age occur exclusively within the Miocene manganese metallogenic province, suggesting that the wad ore is product of regenerating mineralization.

Mineralization of Miocene time in West Hokkaido initially deposited Cu-Pb-Zn-Mn ores at the Toyoha, Oe and Inakuraishi Mines along the axis of so-called Shakotan Dome, and later, Bi bearing Au-Ag-Ba ores were formed at the Teine, Chitose, Koryu, Minami-Shiraoi and Matsukura Mines along the outer zone of the above-mentioned dome. Afterwards, deposition of sulphur took place at the Horobetsu, Abuta and many other mines near the center of

* Green tuff region in NE Hokkaido is frequently called "Kitami metallogenic province".

the dome. Considerable amount of Bi is detected as minor element of the sulphur ores, implying that the sulphur ore may represent the final product of the ore solution that has precipitated the base metals during Miocene mineralization.

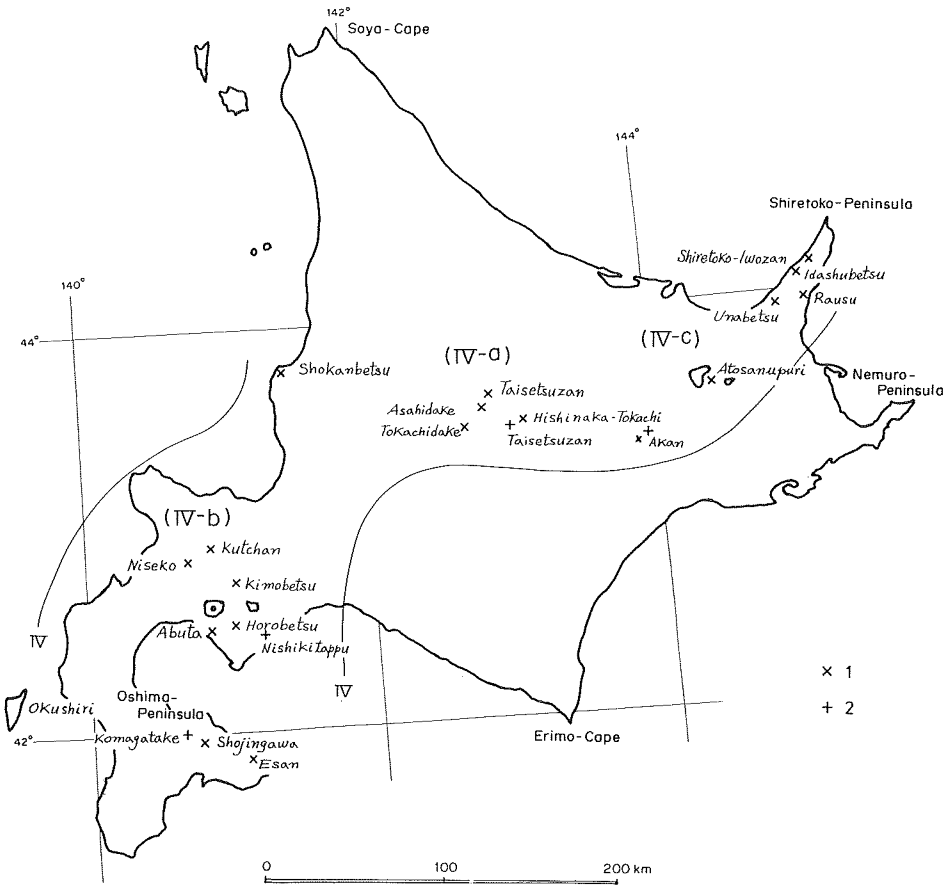

Fig. 5 Metallogenic province of Hokkaido
IV Mineralization of late Neogene Tertiary to Quaternary periods
1 Composite type sulphur, iron-sulphide and limonite deposits
2 Wad deposits

Acknowledgements

The collection of materials for the study of metallogenic province of Hokkaido was carried out during the author had belonged to the Geological Survey of Japan from 1952 onwards until 1975 with cooperation by coworkers: Drs. M. Saito, T. Sawa, E. Narita, K. Yamada and T. Igarashi. The present author would like to express his cordial thanks to above-mentioned colleagues.

It is most regrettable that my beloved wife Mrs. Kazue Bamba passed away on February 27 of this year by acute heart trouble when the manuscript for this paper was being prepared. She was an unexchangeable treasure during my study life and I would like to express my deepest sorrow and pray to the spirit of my late wife Kazue.

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(Received on May 28. 1977)