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CONTACT METASOMATIC ZONE AND MASSIVE ORE BODY IN MANGANESE EPITHERMAL DEPOSITS OF THE JOKOKU MINE, HOKKAIDO, JAPAN

by

Yu Hariya and Kiyoshi Hasegawa*

(with 3 figures, 3 tables and 1 plate)

(Contribution from the Department of Geology and Mineralogy,
Faculty of Science, Hokkaido University, No. 1641)

Abstract

Recently contact metasomatic zone and massive ore bodies were found in the manganese epithermal deposits of the Jokoku mine. Various kinds of contact minerals occur in the contact metasomatic zone which is formed by replacement of the Palaeozoic limestone. The massive ore bodies also formed by replacement of the limestone. These ore bodies are made up of carbonate ore consisting predominantly of rhodochrosite, associated with dolomite, calcite, kutnahorite and small amount of sulphide minerals. The parts of the Jokoku mine studied here belong to the metasomatic deposit type, which has been influenced by early hydrothermal solution.

Introduction

The Jokoku mine, located in Oshima Penninsula of South-western Hokkaido, is one of the largest manganese deposits in Japan. The deposits belong to fissure-filling vein type, mostly deposited under tensional condition and some parts have also net work structure, genetically related to the Miocene igneous activity.

The general geology and the ore deposits of the Jokoku mine are given in detail by Bamba (1957), Miura and Omura (1961), Omura (1962), Sawa (1965) and Nishio (1966). The surrounding area of this mine is composed of Palaeozoic sediments, comprising diabasic tuff, tuffaceous slate, chert and limestone. Miocene rocks in this mine area comprise pyroclastic sediments as well as extrusive rocks such as andesite, propyllite and rhyolite.

Recently contact metasomatic zone and massive ore bodies were found in this mine. The nature of this contact metasomatic zone, and relationship between massive ore bodies and vein type deposits in this mine are discussed in this paper.

Mineralization

The epithermal veins of the Jokoku mine have two main directional trends; the champion vein has the general strike of N40°-45°W and dip of 60°W, and other composite veins have N70°W trend. The veins consist of four stages of mineralization. The early stage mineralization is characterized essentially by rhodochrosite-sphalerite-galena-pyrite-quartz assemblage, and later stage mineralization is characterized by calcite-rhodochrosite-quartz-sphalerite-galena assemblage. In the hydrothermal ore veins, there occur various kinds of ore minerals, such as rhodochrosite, pyrite, pyrrhotite, chalcopyrite, galena, sphalerite, freibergite, argentite, acanthite, pyrargyrite, proustite, pearcite-polybasite series, matildite,

* Geological Survey of Hokkaido

native gold and silver, and gangue minerals of calcite and quartz.

The massive ore bodies in limestone of this mine were first reported by Ota et al. (1969). These ore bodies are made up of carbonate ore consisting predominantly of rhodochrosite associated with dolomite, calcite, kutnahorite and small amount of sulphide minerals. A contact metasomatic zone was recently found in the Palaeozoic limestone near vein type deposits, but no sulphide minerals were found in this zone. This zone was principally formed by the replacement of limestone and tuffaceous slate. Dominant contact minerals involve wollastonite, diopside, garnet and actinolite.

Geological Setting and Mineral Assemblage of Massive Ore Bodies

The main ore deposits comprise two different ore bodies in this mine. One is the epithermal vein type and the other is metasomatic type. Relationship between the vein type and the metasomatic type deposits around the East No. 15 of 80 m Level is shown in Fig. 1.

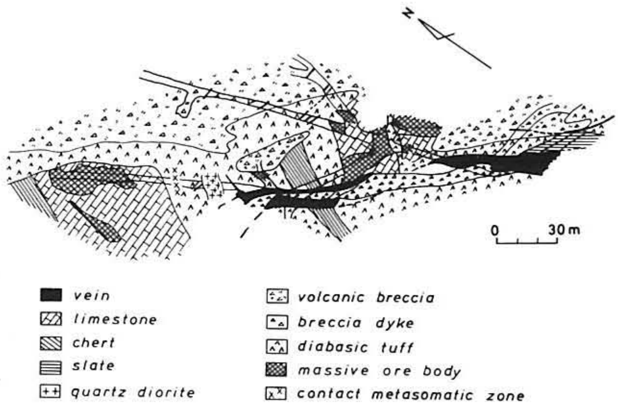

Fig. 1 Schematic sketch showing occurrence of the massive ore bodies and the vein type ore body at 80m level of the Jokoku mine.

This level is composed of Palaeozoic sediments comprising diabasic tuff, tuffaceous slate, chert and limestone. Quartz diorite intrusion cuts the Palaeozoic sediments. Miocene rocks of this level comprise volcanic breccia and breccia dyke. The country rocks of the vein type deposits consist of volcanic breccia and breccia dyke of Miocene age, and slate, chert and limestone. The ore veins occur mainly in the brecciated rock, diabasic tuff and slate. The rhodochrosite mineralization in the slate is of relatively low grade.

As shown in Fig. 1, massive ore bodies usualy found near the vein type deposits, are usualy irregular in shape, and were principally formed by the replacement of limestone. The characteristic feature of these massive ore bodies is absence of the skarn like minerals, such as garnet, diopside and hedenbergite. A sketch of some hand specimen from the massive ore bodies is shown in Fig. 2. Limestone is composed only of pure calcite, but this limestone become dolomitic near the massive rhodochrosite ore. Small rhodochrosite veins of later

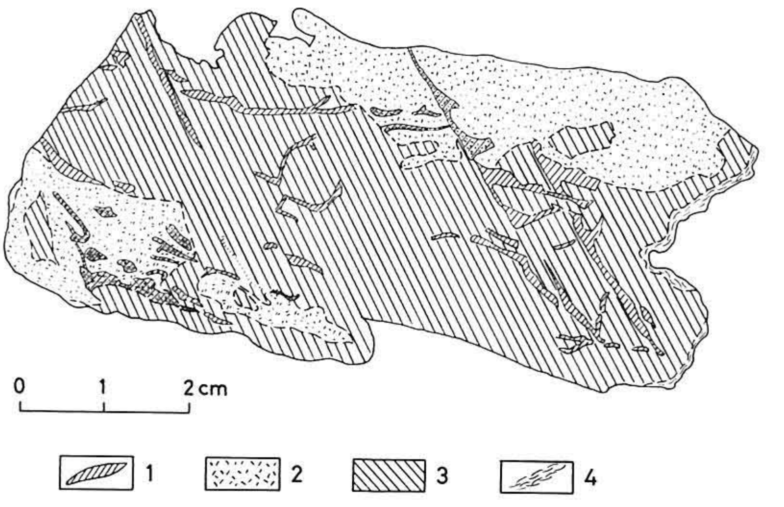

Fig. 2 Sketch of hand specimen of the massive ore.
1. black siliceous zone 2. dolomitic part 3. rhodochrosite 4. dolomite vein

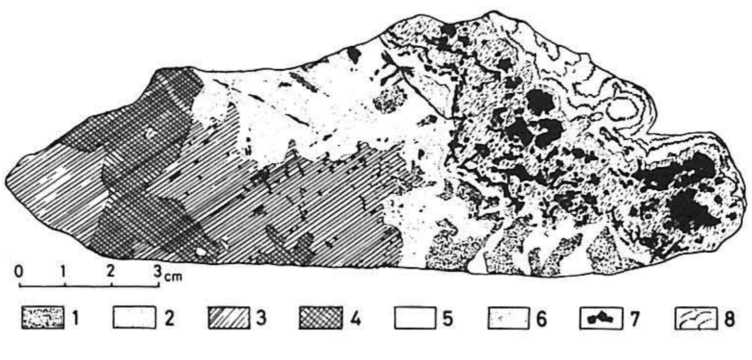

Fig. 3 Sketch of hand specimen showing the relationship between massive metasomatic ore and vein type ore.
1. dolomitic part (grey) 2. dolomitic part (white) 3. rhodochrosite (pale pink) 4. rhodochrosite (pink) 5. dolomite vein (early stage) 6. rhodochrosite vein 7. sulphide mineral 8. dolomite vein (later stage)

stage cut these limestone and dolomitic part. The massive ores contain numerous ragged inclusions of wall rock fragments, as shown in Fig. 2. Mineral assemblage of these fragments in rhodochrosite and dolomitic ores is quartz, calcite, dolomite and rhodochrosite. Relationship between the massive rhodochrosite ore and rhodochrosite veins is shown in Fig. 3. These massive ore bodies are completely cut by veins of a later stage hydrothermal activity.

Kutnahorite occurs as irregular grains, white or pinkish in color, associated with dolomite, rhodochrosite and calcite in dolomitic part (white) of massive ore (Plate 1, A).

X-ray powder data of the kutnahorite are given in Table 1, as compared with data obtained by Miyahisa et al. (1975). The correspondence is fairly good. Chemical analysis of the kutnahorite was undertaken by electron micro-probe. The chemical analysis gave the following composition on the average; MnO 20.19, CaO 28.48, MgO 9.76 and FeO 3.83wt%. The present kutnahorite is a magnesian kutnahorite, characterized by the compositional variation with variable contents of MgO in different grains.

Table 1 X-ray powder diffraction patterns of kutnahorite

Hoei mine (Miyahisa et al. 1975)			Jokoku mine	
hkl	d (Å)	I	d (Å)	I
003	5.423	1		
012	3.733	5	3.73	5
104	2.928	100	2.928	100
006	2.709	1		
110	2.430	3	2.429	5
113	2.217	1	2.222	8
202	2.037	3	2.040	8
024	1.867	2		
018	1.829	5	1.835	8
116	1.808	3	1.818	9
009	1.811		1.818	8

The implication of the modes of formation of the massive ore bodies and rhodochrosite veins will be discussed here. There are four modes of origin estimated from the textural features in the following order: (1) replacement of limestone by Mg-rich solution, (2) formation of massive rhodochrosite ore by replacement of limestone and dolomitic rocks, (3) formation of rhodochrosite vein from epithermal ore solution, and (4) formation of dolomite vein. The crystal sequence of the carbonate minerals is suggested as follows: dolomite → rhodochrosite → magnesian kutnahorite → rhodochrosite vein → vein type dolomite → calcite.

Contact Metasomatic Zone

During the minaralogical survey of manganese deposits in the Jokoku mine, the natural occurrence of various contact metasomatic minerals found at the contact between limestone and quartz diorite by the authors. The skarn minerals were principally formed by the replacement of limestone. The zone comprises wollastonite, diopside, tremolite and small amount of garnet, actinolite and prehnite.

Wollastonite forms euhedral to subhedral, elongated or platy crystals, identified easily by its pure white color and vitreous luster on the well-developed cleavage planes (Plate 1, B). Its x-ray powder data are given in Table 2, as compared with the data obtained by Buerger and Prewitt (1961) by minimizing the effects of preferred orientation. The correspondence is fairly good.

Table 2 X-ray powder diffraction patterns of wollastonite

Buerger and Prewitt (1961)			Kokoku mine	
hkl	d (Å)	I	d (Å)	I
100	7.687	16	7.69	10
200	3.844	31	3.84	41
-201 002	3.519	5 39	3.52	31
-102	3.323	55	3.32	42
210 102	3.094 3.089	8 42	3.09	36
-220	2.981	100	3.04	23
120	2.976	99	2.978	24
-202	2.729	9	2.728	8
300	2.562	10	2.566	16
202	2.479	11	2.481	12
-320 220	2.356 2.352	10 10	2.344	11
-103	2.306	27	2.300	19
3-21	2.187	20	2.185	7
221	2.183	20	2.179	7
-203	2.094	2	2.095	3
-322 -222	2.028 2.026	6 6	2.023	3
362	1.9825	8	1.983	10
400	1.9218	5	1.919	8
-420 320	1.8848 1.8817	5 5	1.879	2
-140	1.8300	40	1.827	5
004	1.7593	17	1.758	15
-323 -2-23	1.7272 1.7258	12 12	1.723	5
322	1.6051	7	1.605	5

Prehnite like mineral occurs as subhedral or anhedral crystals, filling the interstices of wollastonite and is characterized by high refractive index and moderate birefringence. Cleavage are poor (Plate 1, B). A small particle of prehnite picked up from the thin-section, was mounted a Rigaku Denki Micro-diffractometer newly developed in conjunction with micro-focus x-ray generator. X-ray diffraction data were obtained on the following condition: CuKα 45 kv, 25 mA, scanning speed 1 per minute, collimator 100μ, detector scintillation counter. The data are given in Table 3, as compared with the data obtained by ASTM card No. 7-333. Chemical composition of this mineral by electron micro-probe is noted that Al_2O_3 is lower, CaO and SiO_2 are higher than the pure prehnite, while Fe_2O_3 and TiO_2 are present in small amounts.

Other minerals of this zone are garnet (grossular-andradite solid solution), diopside, tremolite, actinolite, epidote, zoisite and small amount of mica.

Table 3 X-ray powder diffraction patterns of prehnite like mineral in thin section by micro-diffractometer

ASTM card 7-333			Jokoku mine*	
hkl	d (Å)	I	d (Å)	I
011	5.28	10		
100, 004	4.60	20	4.60	3
102, 013	4.15	10		
110	3.53	10		
111	3.48	90	3.49	5
112, 104	3.28	60	3.29	6
006	3.08	100	3.09	47
114	2.81	30	2.97	16
022	2.62	5	2.62	100
106, 115	2.55	100	2.55	100
017 116	2.37 2.31	40 40	2.38	51
123	2.18	5	2.18	15
117, 211	2.13	10	2.13	13
108, 204	2.07	20		
118, 214	1.93	30	1.97	5
0010, 215	1.84	20		
119, 220	1.77	70		
130	1.69	5		
217	1.66	20		

$*2\theta=10\text{-}50°$

Genetic Consideration

Based upon the mode of occurrence of contact metasomatic minerals and massive rhodochrosite ore, it is concluded that the mineral assemblage of wollastonite+garnet+ diopside+some amphiboles is a product of the contact metasomatism of the impure limestone. Presence of prehnite like mineral is interesting, since the mineral generally occurs either as metasomatic products of limestone or as vein-filling hydrothermal products. In the present case, the texture indicates that prehnite was probably formed in the later stage of the contact metasomatism, but not in the hydrothermal stage.

The massive ore bodies were principally formed by the replacement of limestone of early hydrothermal stage. From the genetic point of view, the parts of the Jokoku mine studied here belong to the metasomatic type deposit, which has been influenced by early hydrothermal solution. However, this type deposits contain only small amount of sulphide minerals.

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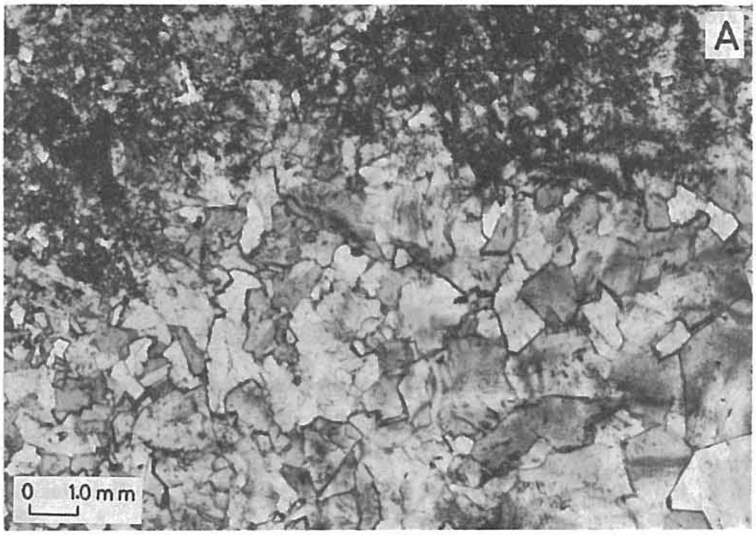

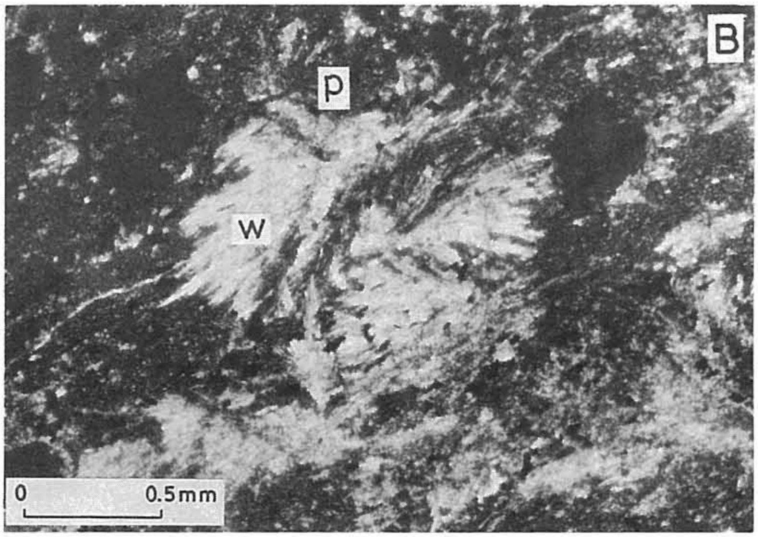

Explanation of plate 1

A. Photomicrograph of the thin-section, showing the mode of occurrence of kutnahorite.

B. Photomicrograph of the thin-section, showing the mode of occurrence of wollastonite and prehnite like mineral (crossed nicols).
W: wollastonite, P: prehnite like mineral

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