Gold deposit and geology of the Chonsan mine, North-Pyongan Province, Democratic People's Republic of Korea

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The gold deposits of the Chonsan mine embedded in Archaean and Proterozoic in Sino-Korean platform are briefly summarized based on geological survey with some drilling data. The main type of deposits is auriferous quartz veins developed along the shear zones with chloritization, silicification and pyritization. Auriferous quartz veins of this mine occur in some fracture zones of migmatite of the Rangnim gneiss complex and of the Ryonhwasan gneissose granite, which are intruded by dolerites of the Namgang intrusives. Gold mineralization of the deposits may take place two stages: (1) magmatism of the Ryonhwasan granite of the third series, and (2) the igneous activity of the Namgang intrusives.

Keywords: Gold deposits, Sino-Korean platform, Auriferous quartz veins, Rangnim gneiss complex, Ryonhwasan granitic rock series, Archaean, North-Pyongan Province, Chonsan mine

I. Introduction

The Sino-Korean Platform is mainly composed of Archaean and Proterozoic high grade metamorphic rocks of igneous and sedimentary origin. Recently Liu *et al.* (1992) reported one of the oldest rocks at Anshan in China near here. The early Precambrian rocks are well exposed in the northwestern region of Korea, where is one of the important areas of gold occurrence. The Archaean strata in the Korean peninsula are represented by the Rangnim Group in the Rangnim Massif, which consists of shade migmatite, various kind of gneisses, granulite, quartzite, marble and amphibolite (Peck *et al.*, 1993). Although this region has been developed during nearly one hundred years as gold producing area, we could not obtain the

detail information on the geology of this area because of lack of communication under severe political circumstances till quite recently.

One of the authors (Kim Yong-Ui) had fortunately an opportunity for prospecting the gold deposits of the Chonsan mine around 1986. There are some gold deposits embedded in the Rangnim gneiss complex and the Ryonhwasan granitic rock series of Archaean in the North-Pyongan Province (Academy of Korea, 1987, 1989). One of them is the Chonsan mine in western part of Mt. Chonma (1,169 m) and the type of deposits is auriferous quartz veins. The Unsan and Daeyudong mines are located at 50 km eastward from Mt. Chonma. The Choyak (Sansei) mine is located at 15 km south-eastward from the Chonsan mine. There are two main faults: the Chonma-Yongsan fault

Fig. 1. Locality map of the Chonsan mine and its vicinity
The enclosed area refers to Fig. 2.

and Kuksonrhyong-Kunjirhyong fault extending NW-SE direction. Many auriferous quartz veins are distributed among the faults (Fig. 1).

This paper outlines geology of this mining area and mode of occurrence of auriferous quartz veins based on the field survey and observation of the drilling cores.

II. Geology

Figure 2 shows geologic map of the Chonsan mining area. This area is dominated by NW-SE and NE-SW trending faults. The Rangnim gneiss complex is separated by the Ryonhwasan granitic rock series. The Rangnim gneiss complex are composed of sericite

chlorite gneiss, siliceous gneiss, graphite gneiss, biotite gneiss and garnet-cordierite gneiss. The Ryonhwasan granitic rock series are mainly formed of gneissose granite (leucocratic granite, biotite granite) concordant with migmatite (Fig. 2). The Namgang intrusive series intruded into the basements at Proterozoic to Paleozoic in age. This series is composed of dolerite, diorite porphyry, lamprophyre, felsophyre, pegmatite and auriferous quartz vein. Auriferous quartz veins occur in some fracture zones of migmatite of the Rangnim complex and of gneissose granite of the Ryonhwasan. They are intruded by dolerite of the Namgang intrusives.

The detail geological map of the mining

Fig. 2. Geological map of the Chonsan area (Chonma geological survey party, 1986).

Rangnim gneiss complex (Agn)

Agn1, Sericite-chlorite gneiss; Agn2, Siliceous gneiss; Agn3, Graphite gneiss; Agn4, Biotite gneiss (containing garnet-cordierite gneiss)

Ryonhwasan granite

r1A, Gneissose granite; r2A, Leucocratic granite; r3A, Biotite granite; mgA, Migmatite

Namgang intrusive series

Na1, Dolerite; Na2, Dolerite porphyry; Na3, Lamprophyre; Na4, Felsphyre; Na5, Pegmatite; Na6, Auriferous quartz vein. The square area refers to Fig. 3.

area is shown in Fig. 3 with the drilling sites. The gold deposits are associated with No. 9 vein in NW-SE direction and with Sambatkol vein in N-S direction. The bonanza is observed in the part of conjunction of the two veins. The fault and fracture zones are of primary importance in controlling of the distribution of gold mineralization. No. 9 vein is embedded in migmatite, gneissose granite and dolerite with shear zones. Auriferous quartz veins are developed along the shear zones with chloritization, silicification and pyritization.

III. Profiles of auriferous veins

Drilling was performed at several spots in this mine. Five profiles of occurrence of auriferous veins in this mine are shown in Figs. 4 and 5 based on the drilling data (2-2', 3-3', 9-9', 11-11' and No. 927) by the drilling machine DIAMIC 260 made in Sweden.

The auriferous quartz veins pinch out in the pit of No. 9 vein as shown in Fig. 5. No. 927 drilling site for No. 9 vein was selected in the pit and the direction of the hole is 200° with 78° dip (Fig. 5). The core of the No. 927 drilling

Fig. 3. Geological map of the Chonsan mine (Chonma geological survey party, 1986). See legend to Fig. 2 for description. D, Dolerite; S, Chlorite shear zone; A, Auriferous quartz vein; Dr, Drilling site; Ad, Adit. Numbers are the same as in Figs. 4 and 5.

from the surface to upper part is migmatite, and the next is dolerite. The shear zones of No. 9 vein were found at 100 m depth. It is hard to obtain the core from there because of the development of fracturing (Fig. 6). This shear zone of auriferous vein is 5 m in thickness. Auriferous veins are concordant to the dolerite intrusives. Intersections of No. 9 vein and the Sambatkol vein are particularly important in gold mineralization. The bonanza of No. 9 vein is convergent with the Sambatkol veins and 30 m in thickness.

Average Au content of ores of this mine is 5 g/ton and that of the high grade ores is 56 g/

Fig. 4. Profiles of No. 9 vein (2-2' and 3-3') and Sambatkol vein (9-9' and 11-11') by the drilling data.

ton. The ore specimen No. 243 of No. 9 vein contains 28.9 Au g/ton and 262.0 Ag g/ton, which was analyzed by Central Research Institute of Mitsubishi Materials Corporation (Table 1). Mineral assemblages of the gold bearing quartz veins are pyrrhotite-arsenopyrite-pyrite-graphite (from the area of the intersections of No. 9 vein and the Sambatkol vein), and chalcopryrite, pyrite and marcasite (from No. 9 vein). Microphotographs of the core of 100.6 m level of the drilling No. 927 are shown in Figs. 7 and 8. The veins have been subjected to chloritization, graphitization, silicification and pyritization. Shear zone steeply dips 70° NE.

The Sambatkol vein is embedded in gneissose granite and dolerite with shear zone. Mineral paragenesis is sphalerite-galena-pyrrhotite-pyrite-chalcopryrite with auriferous

Fig. 5 Profile of No. 9 vein by the drilling No. 927.
The thickness of auriferous veins is variable.
S1, Chlorite shear zone; S2, Chlorite-graphite shear zone.

quartz vein suffered by chloritization and silicification. The Sambatkol veins occurred cross with No. 9 vein or convergent (Chang *et al.*, 1973; Chang and Lee, 1973; Chonma geological survey party, 1986; Kang, 1987; Kim, 1994). The gold deposits are mainly associated with NW-SE trending structure and related secondary shear and fracture zones.

IV. The age of mineralization

According to Peck *et al.* (1993), the Ryonhwasan granitic rock series are divided into three groups such as:

(the first group) the irregular conformable rock body, garnet-cordierite biotite granite, gneissic biotite granite, gneissic granodiorite, gneissic dioritic syenite,

(the second group) the irregular conform-

able, bedded rock body, porphyroblastic granite, porphyroblastic gneissic granite,

(the third group) the injective bedded body, dyke and small batholith, leucogranite, oligoclase-microcline granite.

The granites of the first and second groups are anatexis metasomatic and the third one is the early Lower Proterozoic intrusive rocks. Although the age of the Ryonhwasan series is

Table 1. Analytical results of the ore of the Chonsan mine

Specimen No.	Au(g/ton)	Ag(g/ton)
9-220	2.8	33.4
9-221	9.9	46.8
243	28.9	262.0
909-10	0.4	9.8
908-8	13.1	70.2
123-10	0.2	8.6

AGE	KOREA	Minerali- zation	NORTH CHINA
Phanerozoic	Okchon Group		
Proterozoic	Sangwon Group
	Machollyong Group		Liaohe Group
Archaean	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Ryonhwasan 3rd group granitic rock series </div>		Kuandian Group
	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> 2nd group 1st group </div>		Anshan Gneiss
	Rangnim Gneiss Complex		

Fig. 9. Mineralization epoch of the Chonsan mine.

The gold mineralization of the Chonsan mine is mainly controlled by fracture and shear zones. As auriferous quartz veins are closely associated with igneous rocks as shown in Figs. 4 and 5, magmatism was followed by mineralization.

Although it is impossible to understand the evolution of this area without abundant data of isotopic age, it may be tentatively inferred that the gold enrichment observed in the auriferous veins was occurred in two mineralization epochs. The first stage of mineralization was caused by magmatism of the third group of the Ryonhwasan granitic rock series and the second was by one of the Namgang intrusives.

In the Choyak (Sansei) mine, the ore veins show repeated mineralization or poly-mineralization facies and embedded in gneiss (Simamura, 1936; Chong and Pak, 1972). Dykes of granodiorite porphyry are intruded into the basement. The occurrence of mineralization veins in the Chonsan mine is correlative with that of the Choyak (Sansei) mine. The area of the Unsan mine is underlain by the Rangnim Gneiss Complex intruded by the Tanchon granitic rock series of Mesozoic in age.

The deposits of the Unsan mine were formed as mesothermal-type auriferous veins caused by granitic magma activity (Takashima and Kishimoto, 1987). It seems that the difference of the metallogenic setting in the Chonsan, the Choyak (Sansei) and Unsan mines are related to the variety of the basements.

Those data indicate that the gold enrichment caused mainly by two stages of igneous activities such as the Ryonhwasan and the Namgang for the Chonsan mine, and the Ryonhwasan and the Tanchon activities for the Unsan mine (Fig. 9). This region is the adjacent area of the Liaoning and Jilin region in China belonging to the Yingkou-Kuandian gold province (Trumbul *et al.*, 1992). The gold deposits in this province occur along altered fracture-shear zones as auriferous quartz veins. This is quite similar to gold mineralization of the Chonsan mine.

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朝鮮民主主義人民共和国平安北道の 天山鉱山の地質と金鉱床

猪俣道也・金 容義

中朝古陸の太古代・原生代の地層に胚胎する天山鉱山の金鉱床についてボーリングデータを含めた地質調査にもとづき、その産状をまとめた。富鉱部は鉱脈が複合する所で、主要鉱床タイプは、緑泥石化作用、珪化作用と黄鉄鉱化作用を伴うせん断帯に沿って発達した含金石英脈である。南江貫入岩のドレライトに貫入されている含金石英脈が狼林系のミグマタイトと第3グループの蓮花山花こう岩類のせん断帯に存在することから、第3グループの蓮花山花こう岩の火成活動と南江貫入岩の火成活動の2期に主な鉱化作用があったと考えられる。

Anshan 鞍山, Chonsan mine 天山鉱山, Mt. Chonma (1,169 m) 天摩山, Choyak (Sansei) mine 三成鉱山, Chonma-Yongsan fault 天摩—永山断層, Daeyudong mine 大楡洞鉱山, Jilin 吉林, Liaohe 遼河, Liaoning 遼寧, Machollyong 摩天嶺, Namgang 南江, North-Pyongan Province 平安北道, Okchon 沃川, Rangnim 狼林, Ryonhwasan 蓮花山, Sangwon 祥原, Tanchon 端川, Unsan 雲山, Yingkou-Kuandian 營口—寬甸