Relationship between Volcanic Activity and Epithermal Gold-Silver Mineralization: Example from Kitano-oh Mine Area and Vicinity in Kitami Metallogenic Province, Hokkaido, Japan

Hiroyuki MAEDA*

Abstract: Neogene magmatism in the Kitano-oh mine area and its vicinity in the Kitami metallogenic province is characterized based on the K-Ar data by Late Miocene bimodal land volcanism of felsic and intermediate effusive and intrusive activity. Epithermal hot spring-type gold-silver mineralizations of the Kitano-oh, Shakinzawa, Ikutahara, and Showa deposits are closely related both temporally and spatially to felsic intrusive activity of Maruyama Rhyolite during sedimentation of the Upper Miocene Ikutahara Formation.

1. Introduction

Age data on the mineralization of a hydrothermal ore deposit and its related magmatic activity can provide constraints on the genesis or prospect of the deposit (ISHIHARA and SHIBATA, 1972; UENO and SHIBATA, 1986).

The Kitami metallogenic province, a Tertiary metallogenic province in northeastern Hokkaido, Japan (URASHIMA, 1957, 1961) produces silver, copper, lead, zinc, and mercury, but is primarily known as a gold field. Recent studies have reported the radiometric ages of several epithermal vein- and hot spring-type gold-silver deposits (SUGAKI and ISOBE, 1985; MAEDA, 1989, 1990a, b; MAEDA and KUDO, 1990; URASHIMA, 1992; MIYATAKE et al., 1993; YAHATA et al., 1996) and of many igneous and volcanlastic rocks (KOSHIMIZU and KIM, 1986a, b, c, 1987; MAEDA, 1986; MAEDA and KUDO, 1990; MITI, 1990, 1991, 1992, 1993, 1994, 1995; YAHATA et al., 1994) within this province. However, the relationship between igneous activity and mineralization in this province has not been adequately explained.

The present paper reports the K-Ar ages of two types of volcanic rock from the Kitano-oh mine area and an adularia and quartz mixture from the Ikutahara mine in the Kitami metallogenic province, and discusses the relationship between igneous activity and epithermal gold-silver mineralization.

2. Geologic Setting

The Kitano-oh mine area and its vicinity (Fig. 1) belong to the inner zone of the Kurile arc of the Neogene-Quaternary structural division (MINATO et al., 1956). This area consists primarily of Late Miocene volcanic and volcanlastic rocks. These rocks are found in and around the Monbetsu - Kamishihoro Graben (YAHATA and OKAMURA, 1992).

The basement rock is of the Upper Cretaceous-Paleocene Yubetsu Group, consisting primarily of terrigenous turbidites containing conglomerate, felsic tuff, and pelagic and/or hemipelagic green and red mudstones (HASHIMOTO, 1958; YAMADA et al., 1963; KIMINAMI et al., 1983; IWATA and TAJIKA, 1986; TAJIKA and YAHATA, 1991). This basement rock is cropped out in the eastern and northern regions of the Kitano-oh mine area and its vicinity (Fig. 2).

The Neogene System is of the Upper Miocene Ikutahara Formation (YAMADA et al., 1963; YAHATA and NISHIDO, 1990)(Fig. 2). The Ikutahara Formation, redefined by MAEDA (1996), comprises the Ikutahara Formation defined by YAMADA et al. (1963) without Rhyolite II, the Toyohara Formation defined by YAMADA et al. (1963) without dacite, and a part of Rhyolite III, andesite and basalt defined and described by YAMADA et al. (1963). The redefined Ikutahara Formation unconformably covers rocks of the Yubetsu Group. This formation consists

Received on December 16, 1994, accepted on August 14, 1996
* Department of Civil Engineering, Faculty of Engineering, Kitami Institute of Technology, Kitami 090, Japan
Keywords: Epithermal gold-silver deposit, Hot spring-type gold deposit, Related igneous rock, Kitano-oh mine, Shakinzawa mine, Ikutahara mine, Showa mine.
Fig. 1 Distribution map of epithermal gold-silver deposits around Kitano-oh mine area in Kitami metallogenic province, Hokkaido, Japan. Numerics by deposit names show K-Ar ages (Ma) of deposits (MAEDA, 1990a, the present study; MITI, 1990, 1991; YAHATA et al., 1996).

Fig. 2

primarily of basal conglomerate, sandstone, mudstone, felsic welded tuff, felsic tuff, rhyolite lavas, and andesite lavas such as Seyaushiyama Lava (NOCHI et al., 1967) or Setaniushiyama Andesite (YAHATA and NISHIDO, 1995).

The Neogene intrusive rocks consist primarily of andesites and rhyolites (Figs. 2 and 3). The andesites intrude into sandstone and shale of the Yubetsu Group, and run NE-SW and NW-SE (Fig. 2). The rhyolites are divided into two groups, phenocrystal-poor and -rich ones, based on the rock facies. The former, which consists primarily of Maruyama Rhyolite (MAEDA and KUDO, 1990) located between the Shakinzawa deposit and the Kitano-oh deposit, intrudes into clastic and volcaniclastic rocks of the Ikutahara Formation, and runs NNW-SSW to NE-SW (Fig. 2). This type of rock is characterized by a flow structure and is also associated with a small amount of glassy phase. The latter, which consists primarily of Toyohara (6.71±0.41
Fig. 2 Geological map of Kitano-oh mine area and vicinity in northeastern Hokkaido, Japan. Adapted from YAMADA et al. (1963) and YAHATA (1989) with changes and additions. Numbers by solid squares indicate sampling sites of specimens for K-Ar dating.

Ma: MITI, 1990; 6.7±0.2 Ma: MAEDA, submitted) and Kami-Ikutaharayama (newly named) Rhyolites, intrudes primarily into the clastic and volcanioclastic rocks and rhyolite lavas of the Ikutahara Formation, sometimes runs NNE-SSW to NNW-SSE and E-W as small dikes, and usually has relatively irregular shapes (Fig. 2). These rhyolites are characterized by nevaditic lithology and are accompanied by a spherulitic structure.

The Kitano-oh mine area and its vicinity are located in the "Central Kitami mining district" of the Kitami metallogenic province (URASHIMA, 1957, 1961). This area has been mined or prospected for gold, silver, and mercury for many years. The gold-silver ore deposits, including the Kitano-oh (Monbetsu-Kitano-oh), Shakinzawa, Ikutahara (Kyoei), and Showa deposits are known as "Showa-Kitano-oh"-type (WATANABE, 1940) or hot spring-type (MATSUHISA, 1987). These ore deposits consist of a silica sinter (MAEDA and KUDO, 1990; MITI, 1990; MURATA et al., 1991), an epithermal fissure-filling veinlet-network, and a residual deposit ("Doshako": WATANABE, 1940). The silica sinter consists mostly of quartz with rare kaolin mineral and iron oxides (MAEDA and KUDO, 1990; MURATA et al., 1991).

Two-stage gold-silver veinlet-network mineralizations can be identified based on the modes of occurrence and mineral assemblages of the veinlets and networks (WATANABE, 1940; MAEDA and KUDO, 1990). The early-stage ore is characterized by gold- and silver-bearing quartz-adularia and quartz veinlets and networks. The late-stage ore is marked by gold- and silver-bearing quartz-kaolinite or quartz-alunite-dickite veinlets, which correspond to the clay vein (NORITOMI, 1920) and/or the gold- and mercury (cinnabar)-bearing "Hakudomyaku" (WATANABE, 1940). The veinlets and networks strike N-S, N25°-30°E, and N60°W to E-W, dip ca. 90°, have a width of up to 1.0 m, and pinch and swell irregularly (FUKUTOMI, 1949; BAMBA and SAITO, 1959; FUJIWARA and MATSUI, 1964). They occur primarily in clastic rocks, volcanioclastic rocks, and rhyolite lavas of the Ikutahara Formation, and
are also found in a rhyolitic intrusive rock (Maruyama Rhyolite). These country rocks have been intensely silicified or argillized.

The residual deposit is known as the "Doshako" and is primarily composed of magnetite, ilmenite or hematite, zircon, cinnabar, and "native gold" in order of abundance, with small amounts of limonite and hypersthene (WATANABE, 1940).

3. K-Ar Dating

3.1 Description of dated specimens

Following is a brief description of each analyzed specimen:

Maruyama Rhyolite (Specimen No. 84090603): This rock usually shows the least hydrothermal alteration but has undergone various degrees of local hydrothermal alteration in the Kitano-oh mine area. Macroscopically, this intrusion is gray with a purplish tint and phenocryst-poor, and has a flow-banded structure and a relatively large amount of minute druses parallel to the flow banding. Microscopic examination shows that the phenocrysts of feldspar have been replaced by kaolin mineral. The groundmass consists primarily of an aggregate of cristobalite and sanidine along with volcanic glass. Tridymite and quartz occur in minute druses. Few opaque minerals are present.

The analyzed specimen was fresh, and was collected from a float near the top of Mt. Maruyama (544.5 m), located in the Toyohara area of the Ikutahara district (Fig. 2).

Kami-Ikutaharayama Rhyolite (Specimen No. 83110804): This rock is biotite rhyolite and also occurs as an intrusion. It is light gray in color and phenocryst-rich. The phenocryst consists primarily of coroded quartz and euhedral or subhedral sanidine, plagioclase, biotite, and magnetite. The groundmass is composed of cristobalite, tridymite, magnetite, and volcanic glass.

The analyzed specimen was fresh, and was collected from an outcrop near the top of Mt. Kami-Ikutaharayama (495.4 m), located in the Toyohara area of the Ikutahara district (Fig. 2).

Vein adularia and quartz mixture (Specimen No. 89090709) from the Ikutahara mine: The analyzed specimen was a fine-grained light chocolate-brown adularia-quartz veinlet taken from an outcrop at the Saroma area in the Ikutahara mine (Fig. 2). The veinlet, about 2 cm wide, was found in intensively silicified white lapilli tuff of the Ikutahara Formation, and the rock had a K-feldspar-quartz-pyrite assemblage. The veinlet struck N60°E and dipped 80°NW, where a veinlet striking N20°W and dipping 45°SW was also present.

3.2 Measurements of K-Ar ages

K-Ar age determination of the three specimens was performed at the Central Research Institute, Mitsubishi Materials Corporation. The constants used in the age calculation were \( \lambda_0 = 4.962 \times 10^{-10} \) /year, \( \lambda_e = 0.581 \times 10^{-10} \)/year and \( ^{40}K/K = 0.01167 \) atom% (STEIGER and JAGER, 1977). Error was calculated according to the method described by COX and DALRYMPLE (1967) and NAGAO et al. (1984). The results are shown in Table 1.

4. Results and Discussion

The Late Miocene igneous rocks found in the Kitano-oh mine area and its vicinity belong to the forearc volcanic belt (HORIKOSHI, 1994) and to the Kitami magmatic province (KOKUBU et al., 1994).

Late Miocene magmatism is characterized by bimodal land volcanism of felsic and intermediate
effusive and intrusive activity (Fig.3). Felsic effusive activity included eruptions of pyroclastic flow deposits, ash fall deposits, and rhyolite lavas during sedimentation of the Ikutahara Formation. Felsic intrusive activity included intrusions of Maruyama Rhyolite of 8.0±0.3 Ma (Table 1), Toyohara Rhyolite of 6.7±0.41 Ma (MITI, 1990) and 6.7±0.2 Ma (MAEDA, submitted), and Kami-Ikutaharayama Rhyolite of 6.5±0.2 Ma (Table 1). On the other hand, intermediate volcanism included intrusions of Asahi-toge Andesite of 8.1±0.3 Ma (MAEDA, submitted) and On-neyama Andesite of 7.6±0.5 Ma (MAEDA, submitted), and effusions of andesite lavas such as Setaniushiyama Andesite during the sedimentation of the Ikutahara Formation.

The intrusion ages are also roughly divided into two groups, earlier Late Miocene and later Late Miocene, based on the K-Ar ages of the intrusive rocks (Fig.3).

The earlier Late Miocene (ca. 8.1-7.6 Ma) intrusions are composed of andesites and rhyolites. The andesites consist of Asahi-toge and On-neyama Andesites and the rhyolites consist primarily of Maruyama Rhyolite.

The later Late Miocene (ca. 6.7 - 6.5 Ma) intrusive rocks are of rhyolites, which consist primarily of Toyohara and Kami-Ikutahara Rhyolites.

In the Late Miocene volcanic rocks from this area, the volume of felsic rocks is far greater than that of intermediate rocks.

The Kitano-oh, Shakinzawa, Ikutahara, and Showa hot spring-type gold deposits were found primarily in clastic rocks, volcaniclastic rocks, and rhyolite lavas of the Ikutahara Formation and in Maruyama Rhyolite. These deposits consisted primarily of early-stage gold-silver-bearing quartz-adularia veinlets and networks and late-stage gold-silver-bearing quartz-alunite-dickite veinlets. Two whole-rock K-Ar ages for the early-stage vein adularia and quartz mixtures from the Ikutahara and Shakinzawa mines were found to be 7.7±0.2 Ma (Table 1) and 7.4±0.2 Ma (MAEDA, 1990a), respectively. Thus, the early-stage gold-silver mineralization took place between 7.7±0.2 and 7.4±0.2 Ma. This mineralization was closely related both temporally and spatially to felsic intrusive activity of Maruyama Rhyolite of 8.0±0.3 Ma during the sedimentation of the Ikutahara Formation (Figs.2 and 3).

Acknowledgements: The author is deeply indebted to Dr. T. NAKANO, University of Tsukuba, and the three anonymous reviewers for their valuable suggestions, and to Mr. H. HIRATA of the Kitami Institute of Technology for his laboratory assistance.

The present article was supported financially in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture of Japan (No.06302030) to Professor M. UTADA, the University of Tokyo.

References


FUKUTOMI, T. (1949): Applied geological study (1) and (2) on


浅水性金銀鉱化作用と火山活動との関係
－北海道北見鉱床の北ノ王鉱山地域とその周辺の例－

前田 寛之

要旨：北ノ王鉱山地域とその周辺にみられるフェルシッ クおよび中性のパイモーダルな陸上火山活動の時期は，
全岩K-Ar年代によって，後期中新世であることが明らか
になった。

北ノ王，砂金沢，生田原および昭和鉱床の浅水性温
泉型金銀鉱化作用は，上部中新統生田原層堆積時に，時
空的に丸山流紋岩のフェルシック貫入活動に密接に関係
して行われたと考えられる。

日本語表記：Akebono 畠，Asahino 旭野，Asahi-toge 旭峙，
Chitose 千歳，Fusei 富盛，Hokushin 北辰，Hokuyo 北陽，
Hosei 塔盛，Hyakuho 百宝，Ichinosawa 一ノ沢，Itukahara
生田原，Jindai 神代，Kami-Ikutaharayama 上生田原山，
Kitano-oh 北ノ王，Koki 桶喜，Kunihana 国華，Maruyama
丸山，On-neyama 湯極山，Rubeshibe 留辺裏，Saroma 佐
呂間，Shakinzawa 砂金沢，Showa 昭和，Soryu 双隆，
Taiho 大宝，Tahokoku 泰北，Tenryu 天龍，Tokoro 常呂，
Toyohara 豊原，Yubetsu 湯別。