Chuvashov, B.I., Anfimov, A.L., Soroka, E.I., Yaroslavtseva, N.S. Devonian foraminifers with non-carbonate shell from the ore-hosting sequence of the Saf'yanovka deposit, Central Urals // Lithosphere, 2012. №. 5. P. 114–126 [in Russian].

Korovko, A.V., Dvoeglazov, D.A., Leshchev, N.V. et al. The Saf'yanovka copper-zinc sulfide deposit, Central Urals // In: Geodynamics and Metallogeny of the Urals. Sverdlovsk: UB AS USSR, 1991. P. 152–153 [in Russian].

Korovko, A.V., Postoyalko, M.V., Stepanova, T.I. et al. Stratigraphy and fauna of the Devonian and Carboniferous rocks from the Saf'yanovka ore field, Central Urals // In: Problems Stratig. Paleont. Urals. Yekaterinburg: Ministry of Natural Resources, Inc. UGSE, 1999. P. 136–141 [in Russian].

Petrova, L.G. Middle Devonian Foraminifera of the eastern slope of the Urals // In: Paleozoic West Siberian plain and its mountain frame. Novosibirsk, Nauka, 1981. P. 81–101 [in Russian].

Yazeva, R.G., Moloshag, V.P., Bochkarev, V.V. Geology of the Saf'yanovka sulfide deposit, Central Urals. Yekaterinburg: UB RAS, 1992. 71 p. [in Russian].

Yaroslavtseva, N.S., Maslennikov, V.V., Safina, N.P., Leshchev, N.V., Soroka, E.I. Carboniferous silty claystone from the Saf'yanovka copper-zinc sulfide deposit, Central Urals // Lithosphere, 2012. № 2. P. 106–123 [in Russian].

N. Fujioka[1], D. Ishiyama[2], V. Maslennikov[3, 4], K. Adomako-Ansah[2]

[1] Taiheiyo Cement Corporation, Tokyo, Japan

[2] Center for Geo-Environmental Science, Akita Univeristy, Akita

[3] Institute of Mineralogy UB RAS, Miass, Russia

[4] National Research South Ural State University, Chelyabinsk, Russia

CONTRASTING CHARACTERISTICS OF URAL- AND BAIMAK-TYPE VMS DEPOSITS IN THE URALS, RUSSIA

В статье приводится краткая характеристика геодинамической позиции, структуры, вмещающих пород, околорудных метасоматитов, геохимии руд и изотопного состава кислорода измененных вмещающих пород месторождений уральского и баймакского типа. Сделан вывод о том, что месторождения уральского типа с медно-цинковыми рудами, обогащенными кобальтом и теллуром, локализуются в бимодальных сериях с преобладанием вулканитов основного состава и формируются при температурах 220–320 °С. Месторождения баймакского типа со свинцово-медно-цинковыми рудами, обогащенными баритом, связаны с бимодальными вулканическими комплексами с преобладанием кислых вулканитов в задуговой обстановке и формируются при более низких температурах около 200 °С. Эта разница обусловлена различиями магматической активности и удаленностью от магматического источника.

Introduction

The geology of the area studied is composed of the Silurian oceanic arc complex in the Sakmara allochthon zone, Devonian oceanic arc complex in the Magnitogorsk zone and the East Uralian zone from west to east (Herrington et al., 2005). These areas host arc-related volcanogenic massive sulfide deposits (VMS deposits) of Ural, Baimak, Cyprus and Bessi types. The deposits examined in this study were Molodezhnoe deposit for Ural-type deposits and Alexandrinka and Saf'yanovka deposits for Baimak-type deposits (Fig. 1). The aim of this study was to clarify the geological and geochemical features of ore formation of these VMS deposits in the southern and central parts of the Urals based on geological and mineralogical data, hydrothermal alteration and oxygen isotopic ratios of host rocks.

Geology and mineralization

The geology of the Molodezhnoe deposit is dominated by middle Devonian basalt to basaltic andesite lava, altered massive dacite lava and massive basalt to basaltic andesite lava in ascending order. The dacite lava unit hosts a Cu-Zn-rich orebody. The geology of the Alexandrinka deposit consists of middle Devonian altered dacitic tuff and altered basalt to basaltic andesite lava in ascending

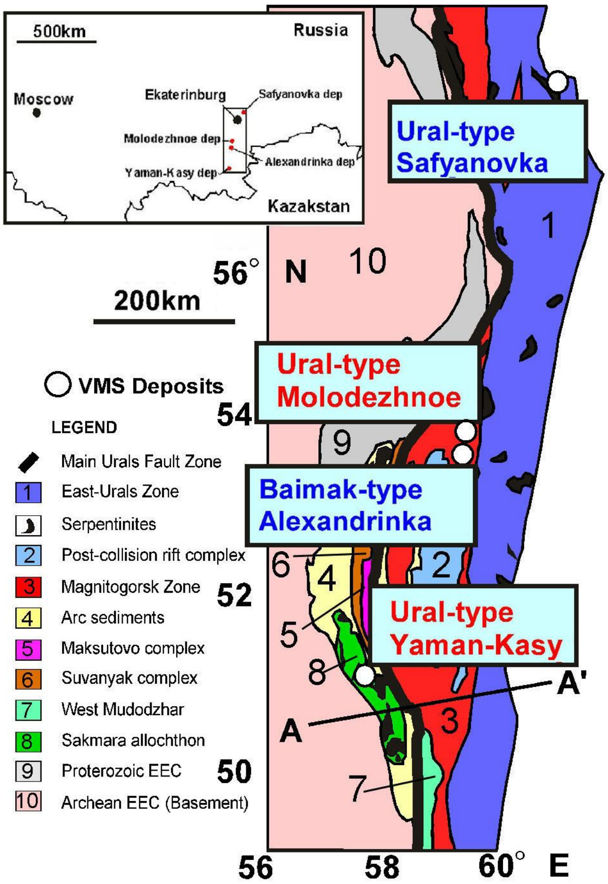

Fig. 1. Simplified geological map of South and Middle Urals (modified from Herrington et al., 2005).

order. A Cu-Zn-Pb-rich orebody occurs in the dacitic tuff. The geology of the Saf'yanovka deposit consists of late Devonian altered dacitic tuff and altered dacitic tuff in ascending order. A lenticular Cu-Zn-Pb-rich orebody of the Saf'yanovka deposit occurs between the dacitic tuff units.

Mineralogical characteristics of ores

The mineral assemblage of ores of Ural-type VMS deposits from Molodezhnoe deposit is characterized by large amounts of pyrite, chalcopyrite and sphalerite with trace amounts of galena and barite. On the other hand, the mineral assemblages of ores of Baimak-type deposits from the Alexandrinka and Saf'yanovka deposits are characterized by large amounts of sphalerite, galena, chalcopyrite and barite with lesser amounts of pyrite. The ores from Ural-type VMS deposits (Molodezhnoe deposit) are characterized by high Cu, Zn, Co and Te and contents low Pb and Ba contents (Fig. 2). The characteristics of ores from Ural-type VMS deposits are similar to those of ores from Cyprus- and Bessi-type VMS deposits, which are related to basaltic volcanic activity. On the other hand, the Baimak-type VMS deposits (Alexandrinka and Saf'yanovka deposits) are characterized by high Cu, Zn, Pb and Ba contents and low Co and Te contents in ores (Fig.2). Those characteristics are similar to those of ores from Kuroko-type VMS deposits associated with felsic volcanic activity. Based on the data of chemical compositions of heavy and rare metals in ores of the deposits examined, Ural-type and Baimak-type VMS deposits are thought to have had a genetic relation with basaltic and dacitic volcanic activities, respectively.

Hydrothermal alteration

Alteration of the Molodezhnoe deposit is divided into three types: quartz-illite-kaolinite, quartz-chlorite-illite and quartz-chlorite alterations. The quartz-illite-kaolinite alteration is recognized

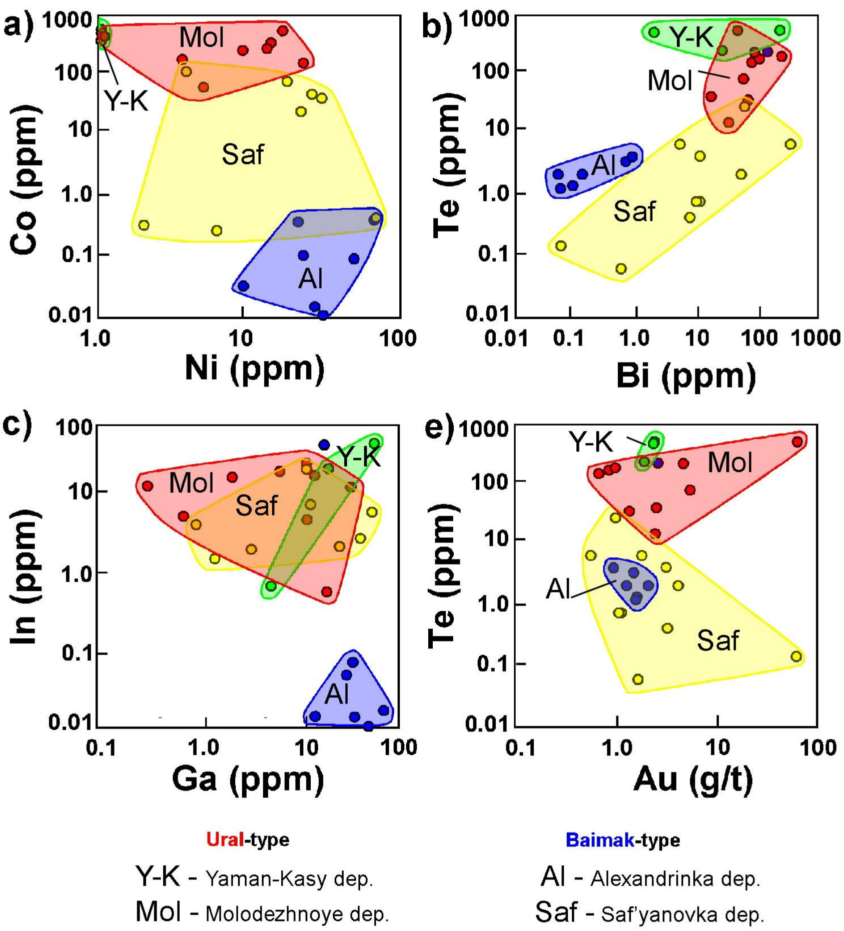

Fig. 2. Characteristics of Co, Ni, Te, Bi, In, Ga and Au contents in ores from the Yaman-Kasy, Molodezhnoe, Alexandrinka and Saf'yanovka deposits.

in a strongly altered zone located immediately below the orebody of the Molodezhnoe deposit. The quartz-chlorite-illite alteration zone surrounds the quartz-illite-kaolinite alteration zone. The quartz-chlorite alteration is the dominant alteration of the deposit and is widely distributed outside the quartz-illite-kaolinite alteration and quartz-chlorite-illite alteration zones. Based on the stability of clay minerals [Inoue, 1995], the Molodezhnoe deposit was formed at a temperature of 220–350 °C. Alteration of Alexandrinka deposit is divided into two types: quartz-illite/montmorillonite mixed layered mineral-chlorite and quartz-illite-chlorite alteration zones. The quartz-illite/montmorillonite mixed layered mineral-chlorite alteration is distributed in the footwall of the orebody of the deposit. Alteration of the Saf'yanovka deposit is divided into three types: quartz-illite-chlorite, quartz-illite-kaolinite and quartz-illite/montmorillonite mixed layered mineral alteration zones. The alteration zones of the Alexandrinka and Saf'yanovka deposits are thought to have been formed at 220–250 °C on the basis of thermal stability of clay minerals and the mineral assemblage.

Oxygen isotopes

The $\delta^{18}O$ values of footwall basalt, footwall dacite and hanging wall basalt of the Molodezhnoe deposit range from +3.8 to +7.5 ‰, +6.0 to +9.3 ‰ and +5.5 ‰, respectively (Fig. 3). Calculation based on an isotopic exchange model (Taylor, 1972) suggests that the Molodezhnoe deposit was formed at high temperatures of approximately 180–320 °C in seawater. The $\delta^{18}O$ values of footwall dacite of the Alexandrinka and Saf'yanovka deposits range from +8.9 to +12.1 ‰ and +8.8 to +12.9 ‰, respectively (Fig. 3). The Alexandrinka and Saf'yanovka deposits were formed of low temperatures of approximately 140–190 °C compared to the formation temperature of the Molodezhnoe deposit in seawater. The temperatures estimated from O-isotopes are generally consistent with those estimated from clay mineral stability for each deposit.

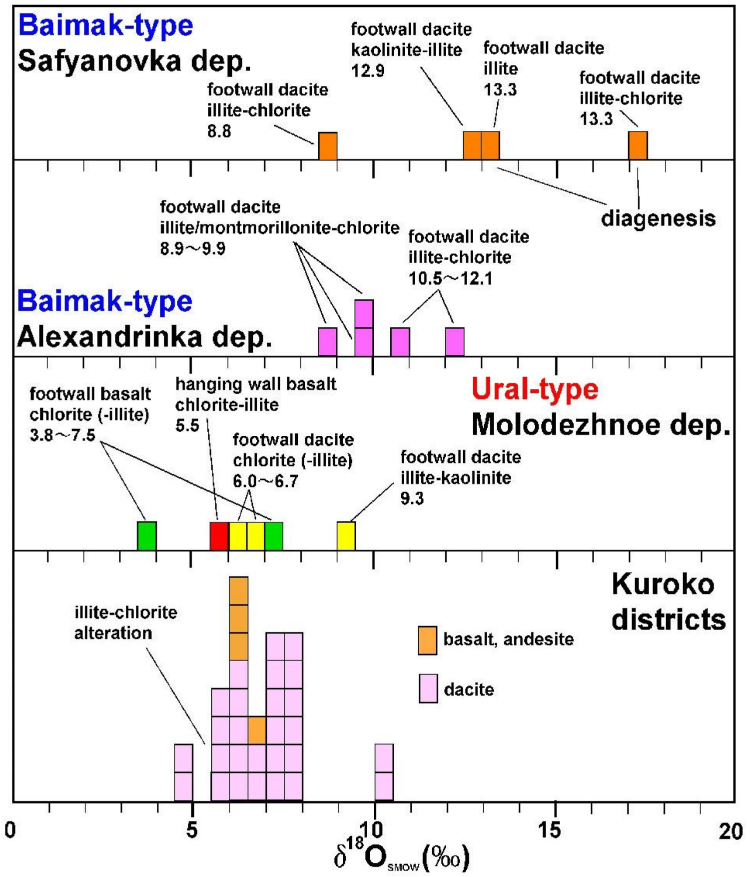

Fig. 3. δ ^{18}O values for volcanic rocks of Saf'yanovka, Alexandrina and Molodezhnoe VMS deposits (this study) compared with δ ^{18}O values of volcanic rocks for Kuroko VMS deposits [Green et al., 1983].

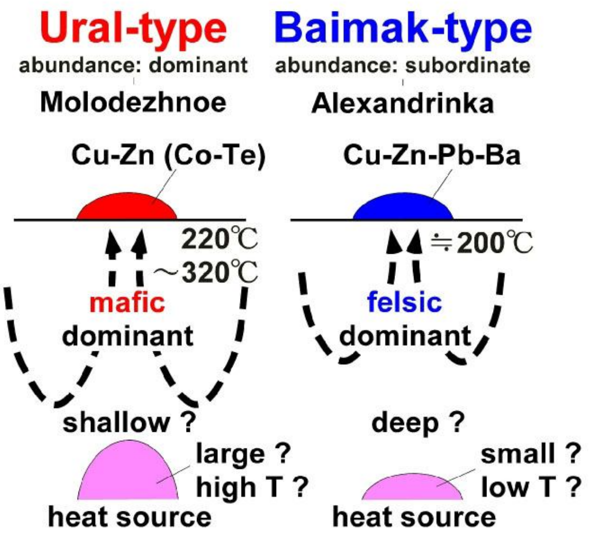

Fig. 4. Schematic model for the Ural- and Baimak-type VMS deposits in the Urals, Russia.

Summary

Fig. 4 illustrates the formation environment of Ural-type VMS deposits (Molodezhnoe deposit) and Baimak-type VMS deposits (Alexandrinka and Saf'yanovka deposits) as proposed in this study and is summarized as below.

The abundant Ural-type VMS deposits (e.g. Molodezhnoe) containing Cu and Zn (Co, Te)-rich ores were formed at relatively high temperatures of 220–320 °C associated with large mafic-dominant bimodal volcanic activity close to the volcanic front of an oceanic volcanic arc setting. On the other hand, the surbodinate Baimak-type VMS deposits (e.g. Alexandrinka and Saf'yanovka) associated with Cu, Zn, Pb and Ba-rich ores were formed at relatively lower temperatures of approximately 200 °C associated with small felsic-dominant bimodal volcanic activity in a back arc environment of an oceanic volcanic arc setting. The difference between Ural- and Baimak-types is thought to be caused by differences in magma activity or distance between magma and these ore deposits.

References

Green, G.R., Ohmoto, H., Date, J., Takahashi, T. Whole-rock oxygen isotope distribution in the Fukazawa-Kosaka area, Hokuroku district, Japan, and its potential application to mineral exploration // Economic Geology. Monograph, 1983. Vol. 5. P. 395–411.

Herrington, R., Zaykov, V.V., Maslennikov, V.V., Brown, D., Puchkov V.N. Mineral Deposits of the Urals and Links to Geodynamic Evolution // Economic Geology., 2005. Vol. 100. P. 1069–1095.

Inoue, A. Formation of clay minerals in hydrothermal environments // In: Velde, B. (Ed.), Origin and mineral of clays, Springer, 1995. P. 268–329.

Taylor, H.P.Jr. Oxygen isotope evidence for large scale interaction between meteoric ground waters and Tertiary granodiorite intrusions, Western Cascade Range, Oregon // Jour. Geophy. Research, 1972. Vol. 76. P. 7855–7875.

Kaneto F.[1], Murzin V.V.[2], Hoshino K.[1]

[1]Department of Earth and Planetary Systems Science, Hiroshima University, Japan

[2]Institute of Geology and Geochemistry UB RAS, Ekaterinburg, Russia

GOLD-BEARING RODINGITES FROM THE KARABASH ALPINE-TYPE ULTRABASIC MASSIF, SOUTH URALS, RUSSIA

Обсуждаются вопросы состава и генезиса родингитов месторождения «Золотая гора» в Карабашском массиве альпинотипных серпентинитов. Изучены петрография, минералогия и геохимия родингитов по основным стадиям рудообразующего процесса. Особое внимание уделено вопросам анализа состава флюидных включений и зависимости солёности палеорастворов от температуры.

Rodingites occur as inclusions or dykes with serpentinite and are formed by Ca-rich metasomatizm with replacement of primary minerals by zoisite, epidote, diopside, grossularite and vesuvianite. Most rodingites worldwide are barren rocks, but high contents of noble metals, primarily, gold, were occasionally observed in them. Such dynamic transformations correspond generally to (150–450?C) and are now largely ascribed to the hydrothermal circuration taking place at oceanic spreading centers. The rodingite rocks have generally been thought to be derived from mafic igneous rocks. It was also reported that, although in rare cases, some rodingites were metasomatized from intermediate to acidic igneous rocks and even from sedimentary rocks. The geotectonic setting of rodingites occurrences may represent an ancient suture between an oceanic and a continental plate, lending support to the suggestion that serpentinization and rodingitization predate the uplifting of the ultramafic bodies and that they take place in the deeper oceanic crust.

Gold-bearing rodingites in the Karabash alpine-type ultrabasic massif have been mined at the Zolotaya Gora deposit in 1902–1946. Although a number of mineralogical and fluid inclusion studies of the area have been taken in the previous researches, a genesis and a formation condition of cupriferous gold characteristically observed in the deposit has not been clarified yet. In order to solve this problem, chemical compositions of rodingite, rodingite-forming minerals and a placer gold, and fluid inclusions in the rocks were analyzed in this study.

Geological setting the Karabash-alpine-type ultrabasic massif is located in the southern part of the Main Ural Fault Zone, which separates the paleocontinental and paleooceanic segments of the Urals. The massif is a part of a serpentinite diapir, which is confined to the central portion of the