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.

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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 fault zone and represents the extruded melanocratic basement of the Silurian-Devonian volcano-sedimentary complexes of the Magnitogorsk megasynclinorium. The detailed characteristic geological position of the massif and condition of ores localization is provided earlier [Murzin, Shanina, 2007].

Methods XRF qualitative analyses of elements and density measurements of the rodingite, chlorite zone and host serpentinite at the both outcrops were carried out to characterize the compositional changes during the rodingitization. Microscopic observations and EPMA analyses were carried out to identify mineralogical sequences and to determine the chemical compositions of minerals. Microthermometric examinations of fluid inclusions were carried out by using the LinkamL-600K and L-600PM programmable heating-cooling stage.

The rodingites in the Karabash massif consist of garnet, clinopyroxene, chlorite, apatite, sphene and calcite. Two types of diopside were recognized in back-scatter-electron images of the rodingite in the southern outcrop. One is a primary diopside showing a clear and unsystematic chemical zonation, while the other is a secondary one free of clear chemical zonation. Microscopic studies of the rodingite in the southern outcrop have revealed a mineralogical sequence as, from early to late, diopside-apatite-garnet-calcite. The chlorite zone is remarkably developed in the northern outcrop. The rocks contain chlorite, clinopyroxene (diopside) and a small amount of Cr-spinel and magnetite. A thin chlorite vein was also observed between the chlorite zone and the host serpentinite. The veins are presented only by chlorite. Chlorite in the chlorite zone has an unsystematic chemical zonation. An Fe-rich core and Fe-poor rim were observed in diopside in the chlorite zone. EPMA analyses revealed the presence of heazlewoodite (Ni_3S_2), native cupper, anilite (Cu_7S_4), geerite (Cu_8S_5) and covellite (CuS) in the chlorite zone. In the southern outcrops, a thin (1–3 cm) reaction zone composed of chlorite, diopside and calcite was observed between rodingite and the host serpentinite. Serpentinite in the northern outcrop is made up of serpentine, olivine, magnetite, chromite, Cr-spinel and small amount of heazlewoodite, while serpentinite in the southern outcrop consist of serpentine, chlorite, magnetite, chromite and Cr-spinel. EPMA analysis revealed the presence of Fe-rich Cr-spinel (picotite). Olivine crystals are rich in forsterite. EPMA data on the placer gold are shown in Fig. 1. There are two types of the placer gold, the first one contains Au and Ag, and the second one – Au, Ag, and Cu. Both types show chemical zonations, where the core consists of Au-Ag or Au-Ag-Cu alloy, while the rim is almost pure. It is known that Ag solubility in Cu-Au alloys is low due to limited miscibility of components in the Au-Ag-Cu system and increases only with rising temperature. Therefore, the chemical

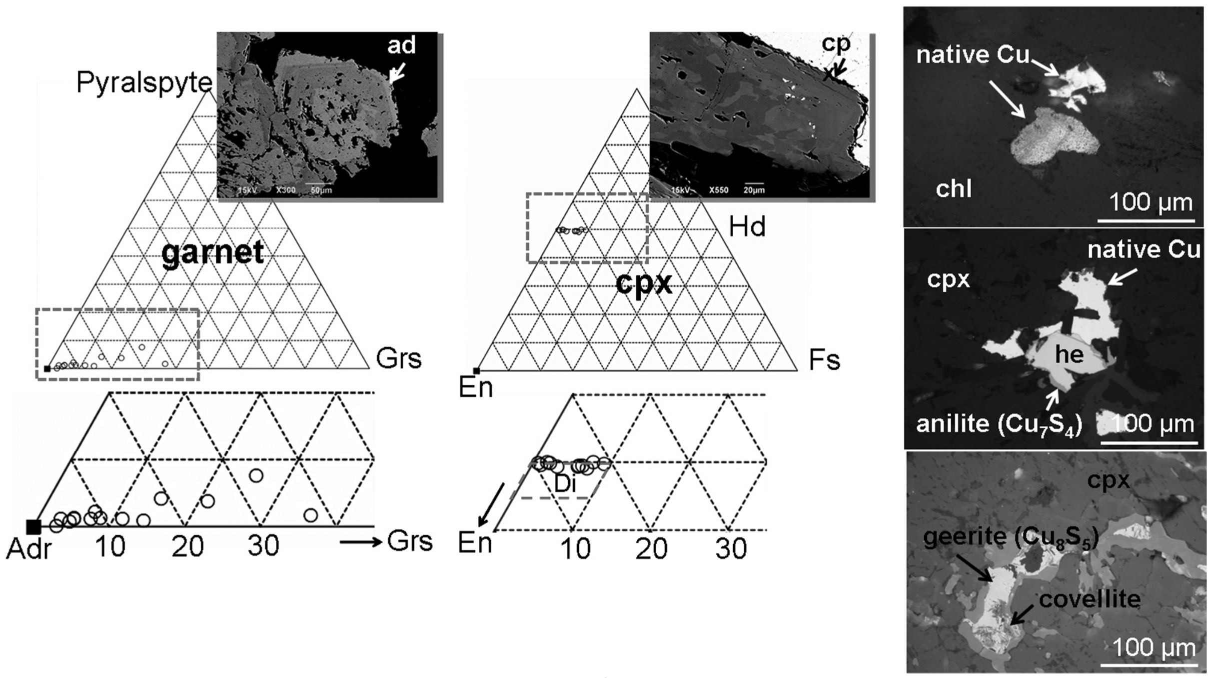

Fig. 1. EPMA analyses revealed the presence of heazlewoodite (Ni_3S_2), native Cu, anilite (Cu_7S_4), geerite (Cu_8S_5) and covellite (CuS) in the chlorite zone.

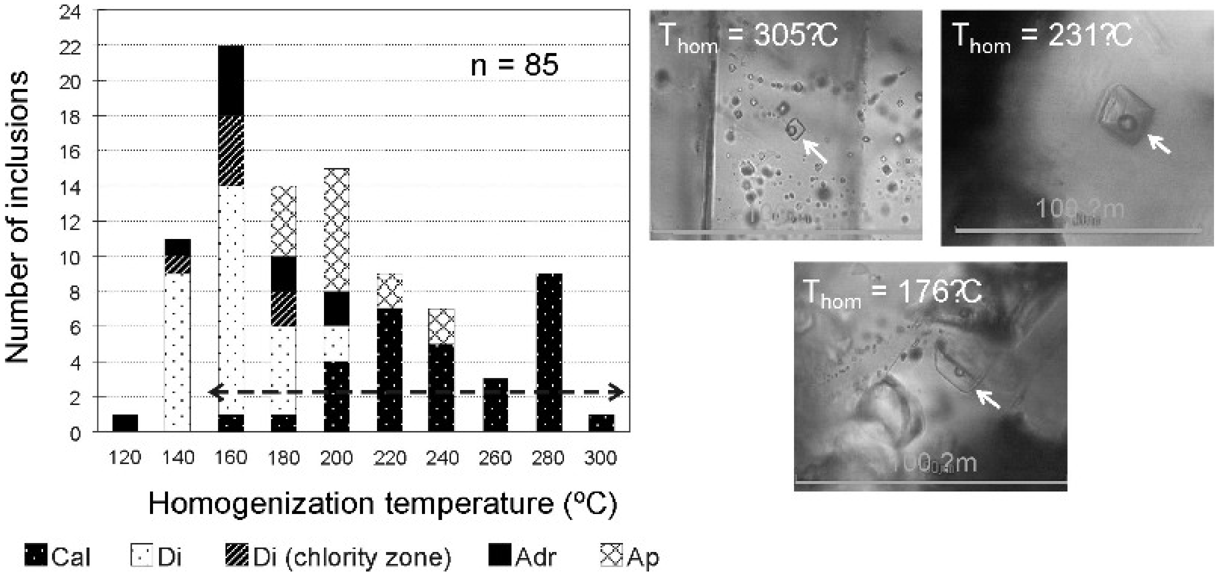

Fig.2. The homogenization temperatures of fluid inclusions in calcite.

composition of the Au-Ag-Cu alloys may serve as a geothermometer. In this study, however the estimation of the formation temperature of the alloys was impossible, because of the low Cu contents in the studied samples.

Most of the fluid inclusions are primary or pseudosecondary and their diameter was less than 35 ?m (Fig. 2). All fluid inclusions were composed of two phases. The primary inclusions in diopside sometimes are distributed along its growth planes. In calcite, several trails of the secondary inclusions cutting the crystals were observed. Most of the fluid inclusions in the minerals were homogenized at 140–200 ?C. The homogenization temperatures of fluid inclusions in calcite varied from 160 ?C to 290 ?C with a peak in the histogram at 270–290 ?C. It should be emphasized that since there is no evidence for leaking of the fluid inclusions in calcite, they may show the proper ones. The homogenization temperatures of fluid inclusions in apatite show slightly higher values than those in diopside and garnet. The ice melting temperatures of the fluid inclusions varied from –0.5 to –6.7 ?C, hence a salinity range was 0.8–10 wt. % NaCleq. The salinities of primary and pseudosecondary fluid inclusions in diopside varied from 2 to 10 wt. % NaCleq. The high-salinity (7–10 wt. % NaCleq.) inclusions occurred in cores of the primary diopside. On the other hand, the low-salinity (2–4 wt. % NaCleq.) inclusions occurred in the rims of the primary diopside and the secondary one. Some of the high-salinity inclusions occurred in Fe-rich part of the primary diopside.

The protolith of rodingite could not been clarified in this study. Conditions of formation of rodingites and fluid evolutions [Murzin, Shanina, 2007] estimated the pressure condition (2–3 kbar) of the early mineralization of rodingite. Considering the pressure condition, the low homogenization temperatures of the fluid inclusions in the early minerals may represent their high formation pressures. On the contrary, the high homogenization temperatures of the fluid inclusions in calcite may indicate alow pressure during its mineralization. The high-salinity inclusions in cores of the primary diopside and the low-salinity inclusions in the rims of primary diopside and the secondary one indicate the decrease of the salinities as the mineralization progresses. Low salinities of the fluid inclusions in the other early minerals, garnet and apatite also imply that the salinity decreased during the early mineralization from diopside to garnet. Based on the above, the salinities of the rodingite-forming fluid(s) decreased during the early mineralization of rodingite. The rodingite-forming metasomatism progressed probably at the stable P–T conditions, while at the last stage of metasomatism where calcite mineralized, the pressure decreased.

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