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AGE AND FORMATION CONDITION OF ORE-HOSTING SEQUENCE OF THE SAF'YANOVKA DEPOSIT, CENTRAL URALS: DATA ON FORAMINIFERS

Раковины фораминифер эйфеля-живета *Parathurammina aff. tamarae* L. Petrova, 1981, *Parathurammina magna* и др. встречаются в породах рудовмещающей толщи Сафьяновского медноколчеданного месторождения (Средний Урал) в интервале глубин от 100 до 200 м. Хорошая сохранность фораминифер, нередкое обволакивание раковин пелитовым материалом, следы продавливания осадков указывают на захоронение раковин в мелководных морских условиях недалеко от места обитания. Видовое однообразие раковин фораминифер свидетельствует о неблагоприятных условиях обитания и мелководности бассейна осадконакопления. На основании этого можно сделать вывод, что породы рудовмещающей толщи формировались в эйфель-живетском мелководном морском бассейне при практически непрерывном привносе вулканогенного материала.

The Saf'yanovka massive sulfide deposit confined to the Eastern Uralian uplift is situated in the south of the Rezh lithotectonic zone. It is localized in the altered Middle Devonian volcanic (rhyolite-dacite) and volcano-sedimentary rocks [Korovko et al., 1991], which are exposed in the open pit (10 km northeast of the town of Rezh). The thickness of the ore-hosting sequence is about 400 m. The main body of massive sulfide ores is 400 m long and 140 m wide. The southern flank of the orebody is strongly pinched out and the northern orebody transits into a series of apophyses, which represent massive and stringer-disseminated sulfide ores. Massive chalcopyrite ores consist of pyrite, chalcopyrite, and sphalerite. Polymetallic ores present in subordinate amount include tennantite, tetrahedrite, digenite, enargite, galena and famatinite and rare marcasite, pyrrhotite, arsenopyrite, and gold. Copper-zinc ores contain high amounts of sphalerite and some galena [Yazeva et al., 1992]. The depth of the open pit now is 170 m. After the depth will attain 200 m, the deposit will be operated by the mines.

A layer of Carboniferous limestones exposed by the open pit in the upper section of the ore-hosting sequence (to a depth of 30 m) contains the Upper Tournaisian foraminifers identified in the core of the wells of P-4, 3030 [Chuvashov et al., 2012]. The Upper Eifellian–Givetian [Chuvashov et al., 2011] non-carbonate foraminifera shells of *Parathurammina aff. tamarae* L. Petrova, 1981 [Petrova, 1981] were found in the underlying carboniferous-siliceous sitly claystones (horizon of 187 m).

The members of carbonaceous-siliceous rocks 0.1 to 1.5 m thick are located at the depths of 187–100 m both in the upper horizons exposed by the open pit and at the deeper levels exposed by mines (southwest of the Saf'yanovka ore field, depth of 200 m). The rocks consist of quartz, plagioclase, chlorite, mica, kaolinite, barite, and pyrite. The organic matter is sapropelic of marine origin [Yaroslavtseva et al., 2012].

The *Parathurammina aff. tamarae* L. Petrova, 1981 foraminifera shells composed of quartz or apatite were found in several outcrops of the carbonaceous-siliceous rocks in the southeastern and southern part of the open pit (horizons 187–100 m) (Fig. 1) [Chuvashov et al., 2011]. The shells have three-layered wall, reduced size and mouths that may be attributed to unfavorable habitat conditions in a shallow marine basin, where carbonate sedimentation was significantly suppressed by additional supply of volcanic material.

An attachment disk found in one of the shell sections points to the attached way of life of foraminifers (Fig. 2). Good preservation of the foraminifera shells, frequent enveloping by clay material, and traces of punching precipitation indicate that the shells were buried in the shallow marine environments near the habitat.

The study of shells on a JSM-6390LV (JEOL) electron microscope equipped with an Inca Energy 450 EDS (Institute of Geology and Geochemistry UB RAS, Yekaterinburg, analyst S.P. Glavatskikh) has revealed that originally they were composed of aragonite, calcite, and organic matter (pseudochitin) and later were replaced by apatite and quartz.

The calcareous *Parathurammina magna* Antropov, 1950 foraminifera shells were found in mine in limestones on the southwest flank of the deposit in a fault zone at the contact with serpentinites (sample SH10/12) at a depth of 200 m (Fig. 3). They also inhabited the Middle-Late Devonian

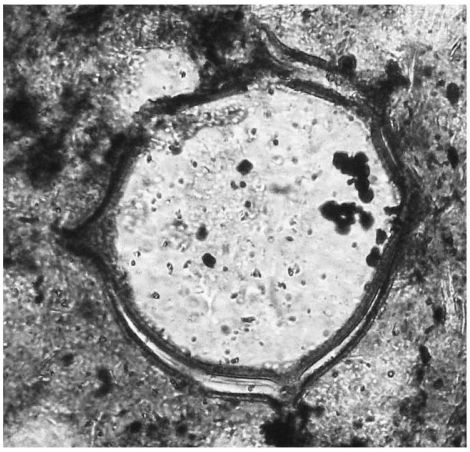

Fig. 1. Non-carbonate (apatite-silicon) shell of Foraminifera *Parathurammina aff. tamarae* L. Petrova of carbonaceous-siliceous rocks of ore-hosting strata of the Saf'yanovka deposit, horizon 187 m. One can clearly see wellhead elevation and three-layer wall of the shell. The Late Eiffelian-Givetian age. Thin section, transmitted light, magnification 140.

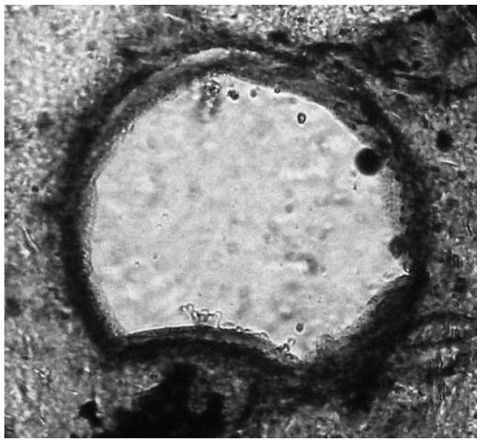

Fig. 2. Non-carbonate shell of Foraminifera *Parathurammina aff. tamarae* L. Petrova with attachment disc, proving that it belongs to the attached benthos. The Saf'yanovka deposit, horizon 187 m. Thin section, transmitted light, magnification 140.

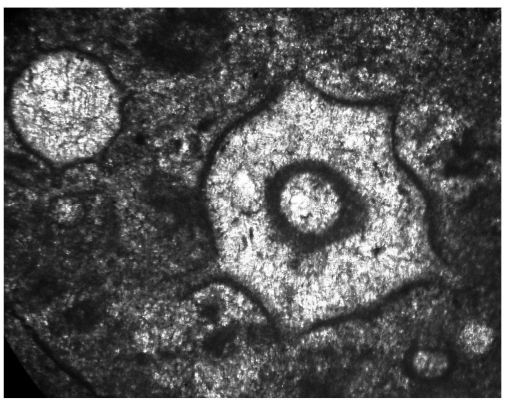

Fig. 3. Carbonate shells of Foraminifera *Parathurammina magna* Antropov with attachment disc in limestone, depth of 200 m, mine of the Saf'yanovka deposit. The Middle-Late Devonian age. Thin section, transmitted light, magnification 140.

shallow sea [Antropov, 1950]. Some specimens have an attachment disk (Fig. 3). Previously, the calcareous *Auroria delineate* L. Petr., *Tamarina corpulenta* L. Petr., *Parathurammina aff. tamarae* L. Petr. foraminifers [Korovko et al., 1999] were found in limestone lenses in wells (M-23, 2142) drilled through the serpentinite melange. The monotony of foraminifera species indicates unfavorable habitat and shallow water basin of sedimentation. The presence of volcanic material in limestones favors for its simultaneous formation with carbonaceous-siliceous rocks from the ore-hosting sequence.

Thus, the volcano-sedimentary rocks of the ore-hosting sequence of the Saf'yanovka deposit were formed in the Eifellian-Givetian shallow marine basin with almost continuous gain of volcanic material. The Eifelian-Givetian foraminifers were found in the ore-hosting rocks at a depth of 100 m to 200 m. According to [Korovko et al., 1999], the Late Lochkovian conodonts were found in the well 2149 at a depth of 298.5–335 m. Consequently, we may expect to find the boundaries between the Lochkovian, Pragian, Emsian, and Eifellian stages at the depths, ranging from 100 to 298.5 m, in case of undisturbed rock bedding.

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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