Ore-bearing hydrothermal systems of deposits from Magnitogorsk metallogenic zone, South Urals: fluid inclusion data

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The formation of VMS and Au-bearing deposits is caused by hydrothermal fluids activity. Their general features are volcanogenic-sedimentary complexes location, Cu-Zn-massive sulphide and Au mineralization, sericite-quartz metasomatic zones and prevalence seawater as fluid source. The aim of our work is to give an overview of the results of fluid inclusion studies of the hydrothermal systems from Magnitogorsk paleo-island arc to establish the history of hydrothermal activity from the bottom to top of this geological structure.

Fluid inclusion data are obtained from barite, calcite and quartz by the use of cryo- and thermometric methods (Borisenko, 1977; Bodnar, Vityk, 1994). We used own and published data.

Magnitogorsk paleo-island arc consists of structural complexes of Urals paleo-ocean suburb (Puchkov, 2000). According to geodynamic reconstructions there are West-Magnitogorsk paleoisland arc, Sibay inter-arc basin and East-Magnitogorsk paleoisland arc. Paleoisland arc ages are different: the west is formed in Eifelian, and the east in Givetian (Artyushkova and Maslov, 1998).

Au-polymetallic VMS deposits in rhyolite-basalt complex of the Baymak ore region are located in the bottom of West-Magnitogorsk paleoisland arc (Zaykov, 2006)

Hydrothermal systems of Tash-Tau and Vishnevka deposits consist of streaky-disseminated ores, sulphide ores of feeder channels filled with calcite and quartz, and quartz veins in supra-ore dacites. NaCl with additions of $MgCl_2$ and $CaCl_2$ with total salinities between 2 and 8 eq mass% NaCl prevail in these hydrothermal systems. The temperatures of homogenization for sulphide-quartz veins from Tash-Tau deposit are between 250 and 300 °C; for feeder channel ores between 160 and 170 °C; for quartz and calcite veins in dacites, andesites and rhyolites from Vishnevka deposit between 120 and 200 °C (Zaykov and Ankusheva, 2008).

Fluid inclusions data of the Balta-Tau deposit are obtained from quartz and barite in streaky-disseminated ores (Holland et al., 2003). The temperatures of homogenization are 140 to 180 °C. First melting temperatures are indicative for the salt systems of NaCl–H_2O and NaCl–KCl–H_2O with total salinities between 3 and 4.5 eq mass% NaCl.

In Severo-Uvaryash deposit barite from Au-bearing sulphide-barite ores in rhyodacites was studied. In Utrenneye deposit Au-bearing streaky-disseminated chalcopyrite-sphalerite and impregnated sphalerite ores with calcite in breccial chloritized rhyolites were studied. In the Zvezdnoye ore mineralization quartz and barite from sulphide veinlets in sericite-quartz metasomatites were studied. Au-bearing barite-quartz-carbonate-sulphide veins from these deposits are formed due to hydrothermal fluids with salinities of 1.8 mass% (Utrenneye deposit) up to 11.9 eq mass% NaCl. (Severo-Uvaryazh deposit). First melting temperatures are indicative for the salt systems NaCl-Na_2SO_4–H_2O (Severo-Uvaryazh deposit), NaCl–H_2O and NaCl–$MgCl_2$–H_2O (Utrenneye and Zvezdnoye deposits). The temperatures of homogenization are between 145 and 170 °C (Zaykov et al., 2010).

Yanzigitovo Mn-bearing deposit in Sibay inter-arc basin is located on the south flank of anticline structure hosted VMS deposits. Hematite-quartz edifice is located in the top of rhyolite-basalt stratum. It is 20 m thick and has a length of 15 to 200 m (Telenkov and Maslennikov, 1995). Dendritic, net-shaped and zonal hematite-containing quartz veins were studied. It is established that hematite-quartz rocks of the Yanzigitovo deposit are formed due to NaCl-fluids with salinities between 2.7 and 6 mass% in a temperature range of 200 to 230 °C.

In the bottom of East-Magnitogorsk paleoisland arc Cu-Zn VMS deposits of Verchne-Uralian ore region are located (Uselga, Chebachye, Talgan, Zapadno-Ozernoye). Fluid inclusion data in ore minerals (barite, quartz, carbonates and sphalerite) and peri-ore rocks indicate temperatures of the ore forming fluid of 110 to 360 °C and salinities of 1 to 10 eq mass% NaCl, with a chloride salt composition and a mixture of hydrocarbonate and sulphide salts (Karpukchina and Baranov, 1995).

The hydrothermal system of Lissy Gory Au-bearing ore field is located in andesite-basalt and siliceous strata in the top of East-Magnitogorsk paleoisland arc. It includes Au-bearing quartzitized zones and hematite-quartz edifices. They formed in NaCl-fluids with salinities of 1.5 to 7 eq mass% NaCl. The temperatures of homogenization are 120 to 290 °C (Ankusheva, 2007).

Thus, all these data allow to describe the history of hydrothermal activity which formed the sulphide and gold mineralization in the Magnitogorsk metallogenic zone.

Massive sulphide forming fluids of the bottom of Magnitogorsk paleoisland arc system (both West and East parts) are similar and have complex salt composition. There are NaCl, KCl, $MgCl_2$ and $CaCl_2$. These fluids are characterized by higher salinities that are caused by magmatic component. The total salinity interval is up 1.8 to 11.9 eq mass% NaCl that is lower and higher than the seawater salinity (*ed. 3.5*).

New fluid inclusion data of hydrothermal systems from Magnitogorsk paleoisland arc system are comparable with data of modern Au-containing sulphide fields from island arc systems of Pacific Ocean. Fluid inclusion data from these localities illustrate salinities of 3.4 to 5.8 (Binns et al., 1993) and 2.7 to 6.9 eq mass% NaCl (Bortnikov et al., 2004) in barite from barite-silica-sulphide chimney Franklin Mountain from Woudlark Basin; 5.3 to 7.2 eq mass% NaCl in barite and anhydrite from sulphide edifice Vensky Wood from Manus Basin and 1.6 to 4.2 in the opaline silica (Bortnikov et al., 2004); 5 eq mass% NaCl in sphalerite from barite-sulphide chimney Vay Lily field, Lau Basin (Herzig et al., 1993); 2.2 eq mass% NaCl (liquid) and 1.74 to 1.98 eq mass% NaCl (vapour) obtained by direct measurements, Brandon field, Rappa Nuy, latitude 21°S, EPU (Von Damm et al., 2003). The temperatures of homogenization are up to 128 ºC in opaline silica in Vensky Wood edifice to 316 ºC in barite of Franklin Mountain edifice (Bortnikov et al., 2004).

According to comparative analysis the salinity of mineral-forming fluids in VMS-bearing fields of paleoisland arc structures from the South Urals is close to modern analogues, and in the systems both seawater and magmatic fluid circulated. The fluid salinity of hematite-quartz edifices from Magnitogorsk paleoisland arc system has confined variations which decrease the role of the magmatic component during final stages of ore hydrothermal system development.

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