COMPARISION OF CRYSTALLIZATION TEMPERATURES OF MINERALS BASED ON ISOTOPIC DATA AND FLUIDE INCLUSIONS

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The sulfur and oxygen isotopic data obtained for the ore minerals are permanently used for the establishment of fluid sources and ore deposition temperature estimates. Sulfide-sulfate pair is mostly productive as its isotopic fractionation coefficient is widely variable at high temperatures [1]. This factor was firstly applied for the ore deposit studies in [2, 3].

Here we report the results of isotopic (S,O) and fluid inclusion (FI) studies of sulfate-sulfide-quartz assemblages in base metal and Pb-Zn ore deposits (Levikha [4], Darasun [5], Zuzel'ga. Aleksandrinskoye). These deposits are characterized by the regular distribution of sulfur isotopic composition points of pyrite and anhydrite on $\delta^{34}S - \Delta^{34}S$ diagram. This indicates that the isotopic fractionation of sulfur isotopes within fluids and above mentioned mineral phases could be interpreted as an equilibrium high temperature fractionation process within 550 - 250^0 C temperature range. This diagram allowed estimating the pyrite and anhydrite temperatures as well as total $\delta^{34}S$ value of the fluid sulfur and ratio $SO^{2-}{}_4/H_2S$. The isotopic composition of the ore forming fluid total sulfur is corresponding to $\delta^{34}S$ value determined as the intersection point of $\delta^{34}S$ of anhydrite and sulfide regression lines. The ratio of oxidized and reduced sulfur forms is evaluated by the inclination angles of sulfide and anhydrite lines in respect of total sulfur line. These values are widely variable in different ore deposits. So the values of $\delta^{34}S$ of fluid total sulfur for Leviha are estimated as +0, 6‰; $SO^{2-}{}_4/H_2S$ - 15/85, T - 520 - 380^{0}C; Darasun (fig.1) correspondingly have +2‰; 30/70; 580 - 400^0; Zuzel'ga (fig 2): -4, 0‰; 20/80; 500 - 200; Aleksandrinskoye: +11‰; 50/50: 500 -350^0. The galena-barite Saurey ore deposit (Polar Urals) [6] were formed from the fluids characterized by the following parameters: $\delta^{34}S$ - 6, 5‰; $SO^{2-}{}_4/H_2S$ - 45/55, T - 65 - 150^{0}C.

Thus, the sulfur sources in the studied ore deposits could be interpreted either a juvenile or sedimentary origin, the fraction of oxidized sulfur being independent of its source.

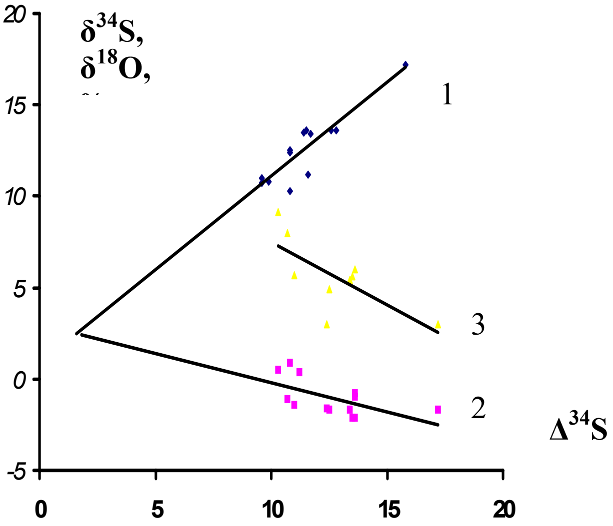

Fig.1. $\delta^{34}S$ *vs* Δ diagram for coexisting sulfates and sulfides from Zuzel'ga ore deposit, Ural, 1 - sulfates, 2. - sulfides, 3. - $\delta^{18}O$ sulfates

The values of $\delta^{18}O(H_2O)$ of fluid aqueous phase were estimated for Darasun and Zuzel'ga ore deposits by use of oxygen isotopic composition of anhydrites and syngenetic quartz and temperature data evaluated by sulfur isotopic geothermometer. The highest $\delta^{18}O$ (H_2O) values as +8‰ corresponding to isotopic equilibrium of the aqueous phase with magmatic rocks at low water/rock ratio are peculiar to high-temperature (580^0C) minerals. Low-temperature anhydrite and quartz were formed from fluids with low values $\delta^{18}O$ (H_2O about +1.4 ‰. This phenomenon could be explained only if to assume the presence of isotopically "light" aqueous solutions in fluid evolution, the "light" water fraction being increased with cooling.

Thus, the surface waters played in important role at the low temperature ore formation; the temperature decreased could be a result of high-temperature fluid mixing with low-temperature water.

Values $\delta^{34}S$ and $\delta^{18}O$ were obtained for quartz and anhydrite FI which were classified as two-phase gas-fluid inclusions with gas phase occupying up to 70% of their volume [5]. Quartz homogenization temperatures ($T_{hom.}$) were evaluated as 440 - 225^0C, the homonisation being proceeded, either to liquid or gaseous phases in samples corresponding to highest temperature values (440-400^0C). This fact allows to concern the obtain $T_{hom.}$, as real mineral-formation temperatures as such kind of TI form within the fluid heterogenisation zone. Some quartz samples contrain also three-phase FI (gas-liquid-halite crystal) associated with the most high-temperature inclusions.

Values $T_{hom.}$ in anhydrite and quartz are consisted within ±30^0C range. So, different FI in anhydrite correspond to 395 - 340^0C interval and in quart being of 370-295^0C.

H. Omoto [7] claimed that the isotopic geothermometry could be used to estimate the real temperature of crystallization, whereas $T_{hom.}$ FI correspond usually to the lowest temperate of mineral deposition.

Our studies demonstrate that for sulfate-sulfide-quartz assemblages in base metal ore deposits isotopic temperature data are also always higher than $T_{hom.}$ FI data are. But for our deposits we suppose that $T_{hom.}$ FI correspond to a temperature of the mixture of fluids with ground waters whereas the isotopic data are related to the primary high-temperature fluids as the cooling proceeds quicker than the isotopic reequilibration.

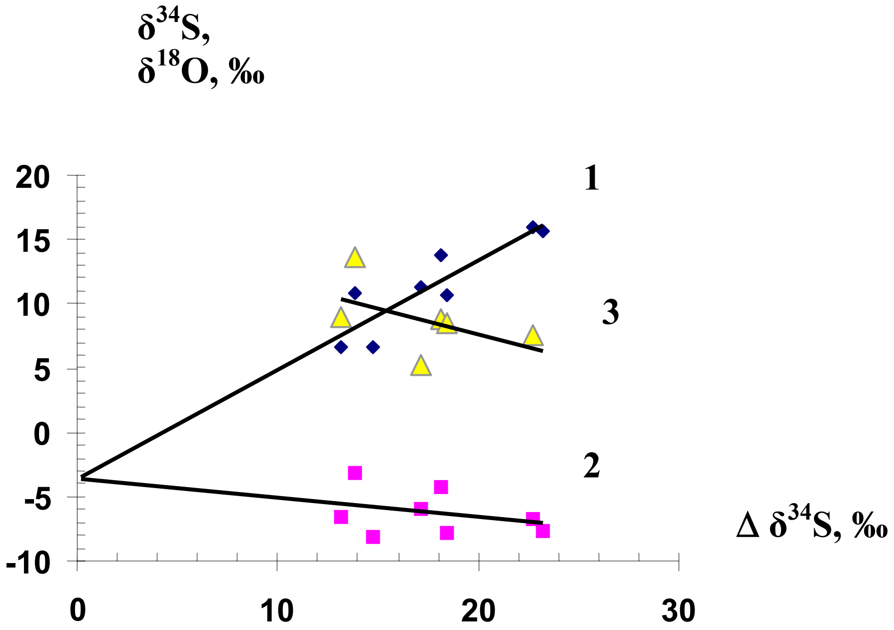

Fig.2. $\delta^{34}S$ *vs* Δ diagram for coexisting sulfates and sulfides from Darasun ore deposit, 1 - sulfates, 2. - sulfides, 3. - $\delta^{18}O$ sulfates

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