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Cu isotope systematics of the MAR hydrothermal fields

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In spite of some progress in studying of transition metal isotope systematics and the natural processes determining their fractionation (Zhu et al., 2002; Albarede, 2004) there are still some problems which remain unresolved (Larson et al., 2003; Maher et al., 2005). One of such problems is the isotope composition of the source of these metals.

The main goal of our investigation was to determine the source of metals for the modern hydrothermal field of the MAR on the base of Cu isotope composition of sulfide ores. The samples used in the study represent 7 hydrothermal fields located in different tectonic conditions on different basement (Logatchev-1, 2; Ashadze, Lucky Strike, TAG, Snake Pit, 16º N, Rainbow). There have been analyzed more then 150 samples of ore and host silicate rocks (basalts and ultramafics). Isotopic measurements were collected on a Neptune MC-ICP-MS using sample-standard bracketing and mass bias correction using a nickel internal standard. The obtained data demonstrate considerable variation of Cu isotope composition within separate ore fields and clear difference in average isotope composition of sulfide ores from different ore field. These variations are higher that those already published for the analogue fields (Zhu et al., 2000; Larson et al., 2003; Rouxel et al., 2004). But variations of isotope composition of the primary sulfides within each ore field are quite restricted (+/-0.5$^{0}/_{00}$ δ^{65}Cu). The absence of obvious correlation between the isotope composition of the studied sulfides and the total Cu content, ore type (massive, spotted, sulfides of black smokers), position in space relative the certain structures (the basement, chimney or disseminated at the distance of dozens of meters) and the age and hydrothermal activity (active, passive, relict) allows to suggest that isotope composition of primary sulfides reflects, first of all, the characteristics of the metal sources (high-temperature ore fluid or magmatic melt). The main variation of Cu isotope composition within the each studied ore field are determined by the fractionation processes caused by evolution of ore fluid, redox-reactions where Cu complexes take part, leaching of Cu isotopes from primary sulfides and redeposition in the secondary ones, by the low-temperature processes of sulfide minerals transformation under the influence of water and bacterial leaching and coincides well with the earlier obtained data (Rouxel et al., 2004; Graham et al., 2004). Maximum shifts towards heavier isotope composition up to $3^0/_{00}$ relatively the coexisting primary chalcopyrites have been observed for the minerals of atacamite group (Logachev-1(2) fields). Thus, sulfides of ore fields developed over ultramafic basement are characterized by more depleted Cu isotope composition and its greater variations in comparison with the sulfides from the ore fields associated with basalts. The most depleted isotope composition (up to -$4.2^0/_{00}\delta^{65}$Cu) characterize the primary sulfides of the ore field 13º N (Ashadze field) with the age of the first high-temperature activity about 200 Ka and developed over ultramafic substrate. At the same time, sulfide ores of the relict hydrothermal field 16º N MAR (basalt substrate) show restricted isotope variations in the range +/-$0.5^0/_{00}\delta^{65}$Cu. It is noteworthy, that the basalts and ultramafics of the MAR show copper isotope composition close to the mantle one ($0^0/_{00}$ δ^{65}Cu), but the host rocks (basalts and ultramafics as well) connected with the ore hydrothermal process are considerably depleted in heavy copper isotope (up to -$1.1^0/_{00}$ δ^{65}Cu).