Trace elements and REE geochemistry of Liuju sandstone-type copper deposit, Yunnan, China

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Liuju sandstone-type copper deposit is located in the Upper Cretaceous (K_2ml_1, K_2ml_2) continental red-bed basin of Chuxiong, Yunnan Province, China. Ore-bodies (average grade: Cu 1.25%, Ag >20g/t) are located in the interface between purple bed and grey bed. From purple bed to grey bed, the ore mineral horizontal zonality is hematite, chalcocite, bornite, chalcopyrite and pyrite.

Based on geochemical data (by ICP-MS) of 9 drills in this deposit, the features of trace elements show that ore-bearing strata are riched in chalcophile elements such as Cu, Ag, Hg, Mo and depleted in Ta, Sc, Co, Ni, V. Ore-forming elements association is Cu, Ag, As, Sb, Hg (K_2ml_1) and Cu, Ag, As, Hg, Mo, Cd (K_2ml_2). Ore-bearing strata are beneficial to preliminary enrichment of metallogenic elements. The K_2ml_1 and K_2ml_2 are the dominant ore source bed. Compared with purple and grey bed, the copper ores are enriched in Cu, Ag, Hg, Mo with low content of high field strength elements (such as Nb, Ta, Zr and Hf).

The average contents of copper ores $\sum REE=86.64\times10^{-6}$, LREE/HREE=4.03, δEu=0.85, δCe=0.92. Chondrite-normalized REE distribution patterns show oblique to the HREE side with the poor Eu and enrichment in LREE. From oxidized zone to transitional zone (purple bed→copper ore→grey bed), ∑REE and δCe decrease gradually with the increase of δEu. The geochemical characteristics well indicate the change of oxidation and reducing environment. These were probably related to the water-rock interaction or infiltration metasomatism.

Results of trace elements and REE analysis suggested that copper metallogenic in the deposit have experienced diagenesis preconcentration and reworked enrichment.

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Experimental studies of microbial Fe(III)-phyllosilicate reduction in subsurface sediments

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The goal of this research is to compare and quantify experimentally the kinetics of Fe (III)-bearing phyllosilicate versus Fe (III) oxide reduction in natural sediments. A key first step was to separate phyllo-silicate and Fe (III) oxide phases in order to permit experimentation with phyllosilicates in isolation. Testing showed that physical separation through density gradient centrifugation did not adequately separate phyllosilicate and oxide phase present in sediment from Area 2 at Field Research Center at Oak Ridge National Laboratory (ORFRC). Hence we examined the ability of chemical extraction methods. Ammonium oxalate in the presence of a small amount of Fe (II) was used to extract both amorphous and crystalline Fe (III) oxides without changing the redox state of phyllosilicates. XRD analysis revealed, however, that both oxalate alone and oxalate with Fe (II) altered the structure of Fe (III)-bearing smectite in the Area 2 sediment. In contrast, citrate-dithionite-bicarbonate (CDB) extraction followed by reoxidation with hydrogen peroxide led to minimal alteration of smectite structures. *Geobacter sulfurreducens* was used to evaluate the microbial reducibility of Area 2 sediments extracted by different procedures. Ammonium oxalate+Fe (II) extracted sediments were reduced more than CDB extracted, H_2O_2 reoxidized solids, consistent with the apparent destabilization of smectite phases during oxalate-promoted dissolution revealed by XRD. CDB extraction was adopted to isolate Fe (III)-bearing phyllosilicates for microbial reduction experiments with ORFRC Area 2 and Atlantic coastal plain sediments from Oyster, VA.