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EPMA study of polymetallic Ni-Mo mineralisation in Lower Cambrian black shales of South China

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Geological Setting

The Lower Cambrian black shale sequence of the Niutitang Formation of southeastern China hosts a conformable polymetallic sulfide layer with an apparently unique and extreme case of metal enrichment. The sulfide layer is extremely enriched in Mo (peak value 7.5%) and Ni (peak value 3.8%). The thickness of the ore layer is commonly a few cm, continuous lateral extent is more than 1000 m, and occurrences of the sulfide layer at approximately the same stratigraphic level are known over a 1600 km long NE trend which follows the paleocontinental margin of the Yangtze craton

Results and discussion

Samples of Ni-Mo sulfide ore were collected from the Sancha, Gangziping ore spot of Zhangjiajie, Hunan, and the Xiaozhuliushui ore spot of Zunyi, Guizhou. EPMA analysis was taken using JXA-8100 Elector Probe X-ray Macro-analyzer at the Nuclear Resource and Enviroment Engineering Center, East China Institute of Technology. Analytical precisions for the concentrations of elements are better than 1%.

The main ore phases are pyrite, pentlandite, bravoite, gersdorffite, vaesite, tetrahedrite, jordisite; the minor ore phases are millerite, sphalerite, chalcopyrite, uraninite, acanthite, galena as well as undertermined REE- and Y-phosphates. The main gangue minerals are quartz, carbonates, clay minerals, apatite and barite.

There discovered many nickel-bearing minerals such as pentlandite, bravoite, gersdorffite, vaesite and millerite in Ni-Mo sulfide ores. At the same time, 0.n%~n% Ni content is detected in pyrite and jordiste. The main host for molybdenum is an amorphous/weakly crystalline Mo-S-C mixed layer phase which is called jordiste in this paper. The Ni-Mo-rich colloidal aggregates (or nodules) are ellipsoidal or spherical in shape, and show recrystallization to very fine-grained mineral assemblages around nodule margins or along fractures.

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Extraction scales of some ore elements (Zn, Pb) from granitic magmas under their degassing

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The exsolution of magmatic fluids from granitic magmas at their rising to the surface and crystallization is one of the most important factors in generation of ore-forming hydrothermal systems genetically related to granitic magmatism. Numerical simulation of Zn and Pb behavior during the degassing of H_2O and Cl-bearing granitic magmas permits to make quantitative estimations of Zn and Pb extraction scales from magmas depending on (1) the pressure of melt saturation with the volatiles, (2) the crystallization degree and (3) dynamics of fluid phase escape from magmatic system. The computer model based on experimental data generalization takes into consideration: a) the dependence of fluid-melt distribution coefficients for Cl, Zn and Pb from pressure and Cl concentration in the system; b) the possibility of fluid phase heterogeneity, i.e. its dividing into essentially aqueous and Cl-rich liquid phases in wide range of PTX conditions. The calculations of Cl, H_2O, Zn, Pb distribution between fluid, crystals and melt in process of degassing were conducted for the systems with varying degree of magmatic system openness. Analysing the process of granitic magma degassing we can distinguish two the most favorable conditions for the formation of magmatic fluids with high chlorine and ore elements concentrations, that are able to extract significant amount of metals from granitic magmas. The first are the earliest stages of melt degassing caused by its rise to the surface and crystallization at $P>1.5-2$ kbar. The second one is magma crystallization at shallow depth (<1.0 kbar) that may be accompanied with the formation of enriched by metals hypersaline brines. The numerical simulation results determine the maximal amounts of ore-forming metals that may be extracted from magma during its degassing. They confirm statement that the quantities of ore-forming metals, extracted by magmatic fluids from granitic intrusions with initially Clarke concentrations of Zn and Pb may be quite sufficient for the formation of very large ore deposits. It should be noted that the total amount of extracted ore-forming elements is essentially dependent upon two factors: firstly, from volatile components concentrations (mainly from Cl concentration for such elements as Zn and Pb), secondly, from the concrete mechanism of fluid phase separation from magmas during its degassing. The capability of magmas to be the ore-forming components source for ore deposits is determined rather by initial content of volatiles and dynamics of fluid phase separation from magma in the process of degassing during its rising to the surface and crystallization than initial ore elements content in magma.