Oxygen-fugacity evolution of magmatic Ni-Cu sulfide deposits in East Kunlun: Insights from Cr-spinel composition

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ABSTRACT

In this study, we use Cr-spinel as an efficient indicator to evaluate the oxygen fugacity evolution of the Xiarihamu Ni-Cu deposit and the Shitoukengde non-mineralized intrusion. Oxygen fugacity is calculated using an olivine-spinel oxybarometer, with spinel $Fe^{3+}/\Sigma Fe$ ratios determined by a secondary standard calibration method using an electron microprobe. Cr-spinel Fe³⁺/2Fe ratios of the Xiarihamu Ni-Cu deposit vary from 0.32 ± 0.09 to 0.12 ± 0.01 , corresponding to magma f_{02} values ranging from $\Delta QFM+2.2 \pm 1.0$ to $\Delta QFM-0.6 \pm 0.2$. By contrast, those of the Shitoukengde mafic-ultramafic intrusion increase from 0.07 ± 0.02 to 0.23 ± 0.04 , corresponding to magma f_{02} varying from $\Delta QFM-1.3 \pm 0.3$ to $\Delta QFM+1.0 \pm 0.5$. A positive correlation between f_{02} and Cr-spinel Fe³⁺/ Σ Fe ratios suggests that the Cr-spinel Fe³⁺/ Σ Fe ratios can be used as an indicator for magma f_{02} . The high f_{02} (QFM+2.2) of the harzburgite in the Xiarihamu Ni-Cu deposit suggests that the most primitive magma was characterized by relatively oxidized conditions, and then became reduced during magmatic evolution, causing S saturation and sulfide segregation to form the Xiarihamu Ni-Cu deposit. The evolution trend of the magma f_{02} can be reasonably explained by metasomatism in mantle source by subduction-related fluid and addition of external reduced sulfur from country gneisses (1.08-1.14 wt% S) during crustal processes. Conversely, the primitive magma of the Shitoukengde intrusion was reduced and gradually became oxidized (from QFM-1.3 to QFM+1.0) during crystallization. Fractional crystallization of large amounts of Cr-spinel can reasonably explain the increasing magma f_{Ω_2} during magmatic evolution, which would hamper sulfide precipitation in the Shitoukengde intrusion. We propose that the temporal evolution of oxygen fugacity of the mantle-derived magma can be used as one of the indicators for evaluating metallogenic potential of Ni-Cu sulfide deposits and the reduction processes from mantle source to shallow crust play an important role in the genesis of magmatic Ni-Cu sulfide deposits.

Keywords: Oxygen fugacity, Cr-spinel, ultramafic rocks, Ni-Cu sulfide deposit, East Kunlun