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Analysis of Controlling Factors for Mineralization, East Kunlun, NW China

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Abstract

The East Kunlun orogenic belt, located in the northeast of Qinghai-Tibet Plateau, is an important metallogenic belt of Cu-Ni sulfide deposits and skarn polymetallic deposit China. Jinshuikou Group and Qimantage Group are the surrounding rocks of these deposits. This study analyzes the factors of formation and magmatic controlling form deposit in East Kunlun orogenic belt formed during Silurian and Devonian period. Jinshuikou Group and Qimantage Group have high content of SiO_2, K_2O and S, which is conducive to sulfur saturation. Not only that, the formation of carbonate rocks and clastic rocks is also conducive to skarn mineralization. The formation time and properties of magmatic rocks has decisive effects on the mineralization specificity. The mafic - ultramafic rocks formed before the Early Silurian have the potential to mineralize Cu-Ni, while those formed after the Middle Silurian do not. The S-type granites are related to W-Sn skarn mineralization, and the I-type granites are related to Fe-Cu skarn deposits.

Keywords

Controlling Factors for Mineralization; NW China.

1. Introduction

The evolution process of Proto-Tethys, Paleo-Tethys and Neo-Tethys in the East Kunlun orogenic belt (EKOB) has been widely recognized [1-3]. Regional geological evolution studies have tried to reconstruct its evolutionary history through ultrahigh pressure metamorphic belts and ophiolites and other geological relics, and regarded the southern suture zone of EKOB as the Paleo-Tethys ocean [4]. Recent studies have found that there are two periods of Cambrian and Carboniferous ophiolites in the EKOB, and some studies suggest that the Proto-Tethys and Paleo-Tethys evolution is a continuous process, which lasted from the Cambrian to the Mesozoic. In fact, the regional unconformity events of the Maoniushan Formation in the Devonian of EKOB indicates that there was an alternating process in the evolution of between Proto-Tethys and Paleo-Tethys, and the Qilian Laojunshan Formation in and the Liuling Group in Qinling, both of which are located in the Tethys tectonic domain, indicate that there was an oceanic and continental transition process in the region at the end of the Early Paleozoic. Wu et al. (2020) pointed out that the Proto-Tethys Ocean between the Tarim and North China plates closed around 440 Ma~420 Ma [5]. However, it is vague when the Paleo-Tethys Ocean cracked after that. In addition, there are few magmatic rocks produced in the Late Devonian and Early Permian in the EKOB, and the lack of key magmatic rocks information also brings many obstacles for us to explore the geological information. Xiarihamu, Binggounan, Shitoukengde, Gayahedonggou, Akechukesai, Langmuri, and Xiwanggou Magmatic Cu-Ni-Co sulfide deposits, which constitutes a magmatic Cu-Ni-Co metallogenic belt with a length of 690 km [6]. At the same time, intermediate-acid magmatic rocks mineralization also shows a great potential, Niukutou, Yemaquan, Kaerqueka skarn deposit has two metallogenic records of Triassic and Devonian (Figure 1). The discovery of Baiganhu and Lalangmai W-Sn deposits indicates that the EKOB has skarn-type tungsten and tin mineralization potential in the late Early Paleozoic to the Early Late Paleozoic. In this paper, we focus on the magmatic Cu-Ni sulfide deposit and

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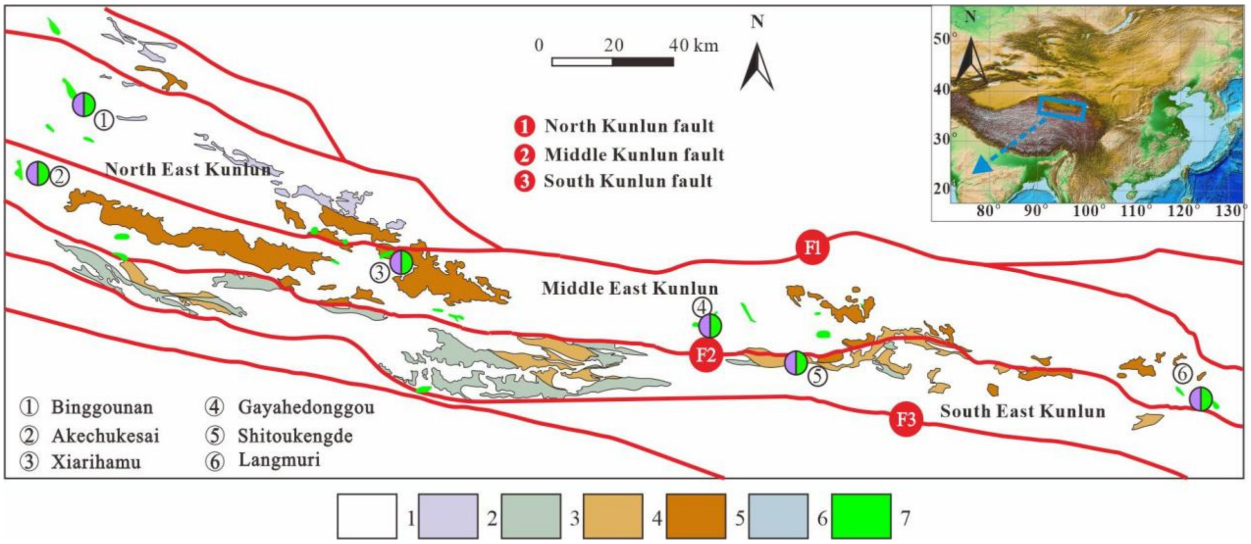
skarn deposit formed at the end of the Proto-Tethys evolution in EKOB from the strata and magmatic to analyze the controlling factors.

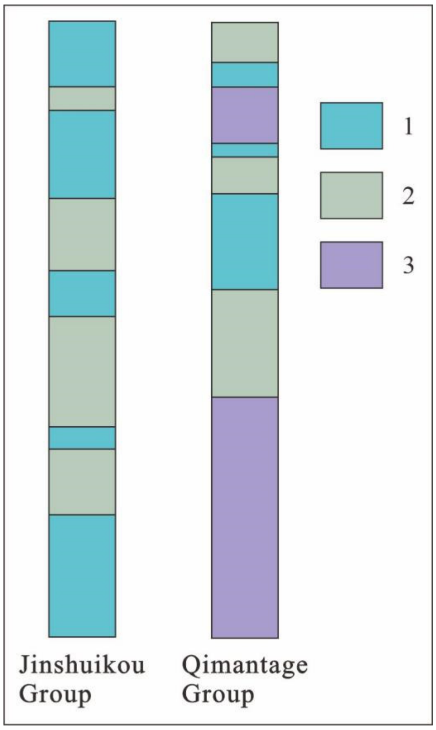


1. Quaternary; 2. Qimantage Group; 3. Nachitai Group; 4. Wanbaogou Group; 5. Jinshuikou Group; 6. Gneiss in the Jinshuikou Group; 7. Mafic-ultramafic rock

Figure 1. Geological map of the EKOB

2. Controlling Factors of Formation Stratum

Both Jinshuikou Group and Qimantage Group have clastic rock-carbonate Formation. According to the stratigraphic construction diagram compiled from the regional borehole data (Figure 2.), the clastic rock construction and carbonate construction in Jinshuikou Group basically produced rhythmically, while the volcanic-carbonate construction in Qimantagage Group.



1. Schist – gneiss; 2. Carbonate; 3. Volcanic

Figure 2. Schematic diagram of formation structure

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Sulfide saturation in the shallow crust of mantle-derived magma is the basis of mineralization, and the mechanism of sulfide saturation is closely related to the oxygen fugacity of the parent magma. The high oxygen fugacity of the parent magma in ore-bearing rocks is not inherited from the oxidized mantle source, but is more likely related to the crystallization evolution of the water-rich magmas from metasomatic mantle. For some small and medium sized magmatic Cu-Ni sulfide deposits in orogenic belts, the ore-forming magma may have high oxygen fugacity. The S isotope characteristics of ore-bearing rocks is quite different from those of ore-bearing strata, but prefer mantle origin characteristics. The C isotope composition of ore-bearing rocks is completely different from that of the mantle, but consistent with that of crustal organic carbon. The results indicate that sulfide saturation does not necessarily require the addition of a large amount of crustal S, and the addition of reducible organic matter in the crust may be an important mechanism leading to the decrease of magma oxygen fugatism and sulfide saturation [7-8]. Li et al. (2016) found that the distribution range of volatile C isotope in Xiarihamu deposit is -23.5%~-5%, which is in the range of mantles and crust C isotope characteristics [9]. Crustal organic matter is mixed in the ore-forming fluid, and crustal mixed S may account for 40 wt%-60 wt% of the total S in the magmatic system [10]. Jinshuikou Group is the main rock mass in the EKOB, followed by Qimantage Group. The content of SiO_2 and K_2O is high, and the content of S is high, which is conducive to sulfur saturation.

Sulfur saturation not only depends on the physical and chemical properties of the strata and magmatic rocks, but also plays an important role in the emplacement depth. The Jinshuikou group has a wide regional distribution and a large thickness. Spatially, the Eastern Kunlun magmatic Cu-Ni sulfide deposits, such as Xiarihamu, Shitoukengde and Binggounan deposits, which located in the southern margin of the Qaidam Basin, while Niubiziliang, Yanchangbeishan and Nanbeigou deposits are located in the northern margin of the basin. Yang et al. (2019) pointed out that in the late Devonian, under the coupling conditions of the deep mantle plume upwelling and the upper Qaidam block covering and insulation, the partially molten mafic magma of the mantle rock invaded the crust along the weak zone in the northern margin of the block, and differentiated into Cu-Ni sulfide deposit [11]. Therefore, the thicker surrounding rock can play an insulating role and contribute to the full saturation of sulfide.

The carbonate rocks in Jinshuikou Group and Qimantage Group have high MgO content and are easy to form magnesium skarn under the influence of hydrothermal. These carbonate rocks often contains mud, iron and other components, resulting in the "impure" characteristics of these carbonate rocks. However, the "impure" carbonate rocks have good permeability, and the higher the permeability is, the greater the surface area of the reaction between the surrounding rock and the hydrothermal fluid is, which is conducive to mineral precipitation. According to the previous exploration and research experience, the favorable position for mineralization is generally near the lithologic change contact zone, and the mechanical properties of different lithologic contact interfaces are relatively fragile, which is prone to mylonization. Moreover, the smaller the thickness of carbonate rocks, the easier it is to form mineralization, and even the whole rock mineralization occurs in the thin carbonate strata. In the middle and downstream areas of the Yangtze River, the theory of interlayer slippage structure has a good explanation of this phenomenon.

3. Controlling Factors of Magmatic

Mineralization time is an important attribute and carrier of mineralization study. As mentioned above, the formation age of ore-bearing rock mass in the magmatic Cu-Ni sulfide deposit in the EKOB is concentrated in 425 Ma~405 Ma, which not only represents the emplacement time of ore-bearing rock mass in this period, but also represents the metallogenic time. The Re-OS isotopic age of sulfide also shows that the sulfide age of Xiarihamu deposit is 408±11 Ma, which is consistent with the geochronology of ore-bearing rock mass. However, not all the basic-ultrabasic intrusive rocks formed in the Silurian and Devonian period have metallogenic potential. The intrusions formed earlier than 428 Ma have no mineralization phenomenon, and the gabbro rocks formed after 400 Ma have no metallogenic potential. There are also obvious differences in lithology. Single gabbro generally does not have metallogenic conditions. At present, the ore-bearing rock facies of Cu-Ni deposits are mostly peridotite facies, pyroxene facies and a few gabbro facies.

The magmatic rocks of skarn deposits have obvious specificity. From Baiganhu deposit in the west to Lalangmai deposit in the east, W mineralization is often associated with S-type granite, and Fe and Cur polymetals are mostly formed in the periphery of I-type granite contact zone. It has been found that the formation age of S-type granite is concentrated between 420 Ma and 427 Ma, and the corresponding tectonic stress background is the compression-extension transformation stage. The favorable formation and magmatic (shallow source) conditions has formed the regional tungsten-skarn deposit. The ore-forming material of Fe-Cu polymetallic skarn deposit is mainly from deep, formed after 410 Ma, and has obvious mantle-derived magma mixing characteristics.

4. Conclusion

(1) Jinshuikou Group and Qimantage Group have high content of SiO_2, K_2O and S, which is conducive to sulfur saturation. The formation of carbonate rocks and clastic rocks is also conducive to skarn mineralization.

(2) The mafic - ultramafic rocks formed before the Early Silurian have the potential to mineralize Cu-Ni. The S-type granites are related to W-Sn skarn mineralization, and the I-type granites are related to Fe-Cu skarn deposits.

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