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Geochronology of the Granitoids Above Nappe Structure in Nanling Scientific Drilling

GUO Naxin[1,2], LÜ Xiaoqiang[3], ZHAO Zheng[2], FANG Guicong[4], CHEN Yuchuan[1] and WANG Denghong[2]

1 Chinese Academy of Geological Sciences, Beijing 100037, China;
2 MLR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, CAGS, Beijing 100037, China
3 China Non-Ferrous Metals Resources Geological Survey, Beijing 100012, China
4 Kunming University of Science and Technology, Kunming 650093, China

1 Introduction

The Nanling Scientific Drilling-1 (abbreviation as NLSD-1) is a subproject of the Sinoprobe Program titled as "Deep Exploration Technology and Experimentation", and is located at Yinkeng ore field, conjunction of Nanling and Wuyi Mountains metallogenic belts (Zhao et al., 2014; Chen et al., 2013; Li et al., 2013). The drilling project, with drilling footage of 2967.83 meters, was started at June 25, 2011 and accomplished at July 22, 2013. Nappe structure (No. F1), which controlled occurrences of intrusions and ore bodies, was uncovered at depth of 1373.71m. Pyroclastic rocks of Kuli Formation of the Qingbaikou System lies above the thrusting nappe structure F1, while marine-terrigenous facies sediments of Leping-Chetou-Xiaojiangbian (Qixia) Formation of the Permian System below. Twenty-nine magmatic dykes, hundreds of lead-zinc-copper-gold-silver mineralized zones and some tungsten-bismuth mineralization were exposed at NLSD-1 project. This paper reports the petrology, geochronology of granitoids above nappe structure, and aims to discuss their significance for research in relationship between magmatic activity and polymetallic mineralization.

2 Geological Background and Granitoids in Drilling NLSD-1

Yinkeng ore field, which is located in Yudu County, Jiangxi Province, possesses significant potential for tungsten - gold - silver - lead - zinc - manganese - copper - polymetallic metallogenesis. Strata exposed include all systems since Qingbaikou except for Ordovician, Silurian and Triassic. NS-trending folds composed by Neoproterozoic Erathem and Cambrian System and NE-trending folds composed by Devonian, Carboniferous and Permian systems are developed in this area. Tectonic framework is characterized by superposition of NE-, NW- and nearly NS-trending faults on EW- and NNE-trending ones, which makes the geomorphology of this area look like a chessboard. Magmatic activities of Caledonian, Indosinian and Yanshanian mostly occurred as acid and intermediate-acid batholith, stock, boss and dyke. Tungsten-polymetallic deposits occur in contact zone around granite batholith at edge of the ore field, while gold-silver-lead-zinc-polymetallic deposits within the ore field. Both of the two types of mineralization are closely related to magmatic activities during Yanshanian Period.

Three types of granitoids (rhyolite, granite and granodiorite) expose upon the nappe structure F1 in drilling NLSD-1, and exhibit porphyritic texture.

Rhyolite porphyry is dominated by quartz (1-2%) and alkaline feldspar (1% ±), and appears as pink or brick red in hand specimen. Quartz is found to be round or harbor, while alkaline feldspar has been completely altered into clay minerals. The matrix (98% ±) displays microcrystalline-cryptocrystalline texture, consisting of quartz, alkaline feldspar and plagioclase. Fluidal structure in the rock is performed by layers with different contents of altered alkaline feldspar, appearing as dark stripes with pale ones.

Granite porphyry has the same mineral assemblage as rhyolite porphyry, and looks pink in hand specimen. The most obviously difference between granite and rhyolite in drill cores is the former does not display fluidal structure.

The color of granodiorite porphyry is gray and pinkish. Phenocryst is dominated by quartz (1-10%), plagioclase (3-10%), alkaline feldspar (0-4%), hornblende (2-12%) and biotite (2-7%). The matrix displays cryptocrystalline

* Corresponding author. E-mail: guo.naxin@163.com

texture, and consists of quartz, plagioclase and alkaline feldspar. Accessory minerals include apatite, zircon, magnetite and pyrite. Alteration, such as argillization, silication, sericitization, chloritization, epidotization and carbonatization, can be commonly seen.

3 Results and Discussion

Three types of porphyry were collected from the drilling NLSD-1, and prepared for LA-MC-ICP-MS zircon U-Pb dating.

The zircon CL images show that grains are euhedral-subhedral and 50-250μm in length, and have oscillatory magmatic zonings. Most of the zircons show variable Th (45-1120ppm) and U (90-2728ppm) concentrations, with Th/U ratios ranging from 0.1 to 2.34. These Th/U ratios are consistent with that of magmatic zircons, but higher than that of metamorphic zircons (Wu et al., 2004).

Most of the U-Pb analyses are clustered in group on or near concordia curve and yield a weighted mean $^{206}Pb/^{238}U$ age of 446.3±3.8Ma (n=17, MSWD=0.40) for granite porphyry, 379.4±1.9Ma (n=12, MSWD=1.60) for rhyolite porphyry, and 160.3±0.8Ma (n=9, MSWD=0.81) for granodiorite porphyry, respectively. They were considered to be products of magmatism of Caledonian, Hercynian and Yanshanian period.

The South China is characterized by great granite province and large-scale tungsten-tin-polymetallic metallogenesis. Large-scale tungsten-tin mineralization in Nanling region occurred at the Middle-Late Jurassic (165-150Ma), and was closely related to biotite granite, which was formed at 165-152Ma. Huameiao quartz vein-type and Yanqian skarn-type tungsten deposits are responses to the Mesozoic metallogenesis in Yinkeng ore field.

Copper-lead-zinc-gold-silver-polymetallic deposits in South China, such as Dexing, Qibaoshan, Shuikoushan, etc., which have close relationship with granodiorite magmatism, mainly distribute near regional deep fractures or at rift zones. These granodiorite emplaced at 179-160Ma, and related mineralization occurred at 170-160Ma. Huge mineral enrichment depends on varies of factors, during which the greater the involvement of mantle material (or basic material in the deep), the higher the chance of concentration of copper and gold. For example, both of ore-forming granodiorites of Dexing copper deposit and Zijinshan copper-gold deposit display features of mixing of crust and mantle (Shen et al., 1999; Zhang et al., 2003). Concentration of lead and zinc mainly depends on contribution of crust, especially old continent crust (Li et al., 2013). Gold-silver-lead-zinc mineralized veins in Yinkeng ore field occurred in structural fractures or fracture zones in Qingbaikou System, accompanying Yanshanian granite and granodiorite dykes. And contact-type copper-gold mineralization developed around Gaoshanjiao granodiorite intrusion. In the context of subduction of Pacific Plate in Yanshanian, Qingbaikou System was pushed onto Late Paleozoic strata, and magma in the deep emplaced along nappe structure and derived cracks. Sulfide hosted in Qingbaikou strata, activated and then extracted during this process, was concentrated to form ore bodies together with ore-forming elements in magma. So far, granodiorite porphyry exposed in the drilling NLSD-1 all occurred as dykes, indicating that hidden granodioritic intrusion probably exist below, and the ore field has potential for skarn-porphyry-type copper-gold mineralization.

Caledonian granite, the largest scale after Yanshanian granite, was supposed to have little relationship with metallogenesis. In recent years, studies show that the previous view might be incomplete. During orogenesis in the Late Caledonian, ore-forming elements concentrated in predevonian strata were activated and migrated, and mineralization might occurred, such as tungsten-tin mineralization in Shangyou intrusion and Yuechengling skarn-type scheelite deposit (Cheng et al., 2013). Although metallogenic granitic bodies in Yinkeng ore field were all formed in Yanshanian Period, Caledonian magmatic activity, and Hercynian magmatism which resulted in rhyolite porphyry, the new type of granite unveiled in Yinkeng region, had great significance for accumulation of ore-forming elements and final mineralization in Yanshanian.

4 Conclusions

(1) Three type of granitoids were exposed above nappe structure in Nanling Scientific Drilling: rhyolite porphyry, granite porphyry and granodiorite porphyry, and the rhyolite porphyry was uncovered for the first time in Yinkeng ore field.

(2) The crystallization ages of granite, rhyolite and granodiorite porphyry are 446.3±3.8Ma, 379.4±1.9Ma, and 160.3±0.8Ma, respectively, indicating that they are products of Caledonian, Hercynian and Yanshanian magma activities.

(3) Gold-silver-lead-zinc mineralization in Yinkeng ore field is closely related to granodiorite (porphyry) in time and space, suggesting that hidden granodiorite body and skarn-porphyry-type copper-gold mineralization are predicted to exist.

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