3D electrical structure of porphyry copper deposit: A case study of Shaxi copper deposit*

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Abstract: Located in Lu-Zong ore concentration area, middle-lower Yangtze metallogenic belt, ShaXi porphyry copper deposit is a typical hydrothermal deposit. To investigate the distribution of deep ore bodies and spatial characteristics of host structures, an AMT survey was conducted in mining area. Eighteen pseudo-2D resistivity sections were constructed through careful processing and inversion. These sections clearly show resistivity difference between the Silurian sandstones formation and quartz diorite porphyry and this porphyry copper formation was controlled by the highly resistive anticlines. Using 3D block Kriging interpolation method and 3D visualization techniques, we constructed a detailed 3D resistivity model of quartz diorite porphyry which shows the shape and spatial distribution of deep ore bodies. This case study can serve as a good example for future ore prospecting in and around this mining area.

Keywords: AMT, 3D resistivity characteristics, porphyry copper deposit, Kriging interpolation, 3D visualization

Introduction

With ever-diminishing shallow mineral resources, deep ore deposits have become the main focus of global resources exploration. As one of the main tools for prospecting deep ore deposits, electromagnetic methods, such as the audio magnetotelluric (AMT) method, complex resistivity method (SIP or CR), magnetotelluric sounding method (MT), transient electromagnetic method (TEM) and controlled-source audiagnetotellurics (CSAMT), have been subjects of many research projects. Gasperikova et al. (2005) used natural field induced polarization method (NFIP) to detect sol-sulfide deposits covered by a low-resistivity layer and Heinson et al. (2006) used MT investigate a deep-crustal mineralizing system beneath the iron oxide copper-gold deposit in the Olympic Dam, southern Australia. In the western part of Athabasca Basin, Grant et al. (2008) used electromagnetic array profiling (TEM and MT) to explore the electrical structure of the Precambrian basement under the Shea uranium mineralized zone. Using MT, Pospeeva (2008) distinguished the different scales Kimberlite magmatism in the Malaya Botuobiya and Zimnii Bereg kimberlite mineral areas in Russia. Audio-frequency magnetotelluric sounding (AMT) and MT have the same principles (Cagniard, 1953) and belong to the family of passive source electromagnetic method. AMT has been widely used in the ore exploration (Strangwayet
Chen et al., 1973, 1979; Lakanen, 1986; Jones et al., 2003; Bronner, 1992; Grant et al., 2008), geological structure study (Valla, 1991) and geothermal resource exploration (Santos, 2006). AMT applications in China are also abundant. Examples include tracking the tectonic system strike of deep gold mineralization (Liu et al., 2004), revealing the shape of deep rock body of massive sulfide Cu-Zn mine (Meng et al., 2006) and distinguishing the facies belts of basic-ultrabasic rock bodies of Cu-Ni sulfide deposit from magmatic segregation (Shen et al., 2007). Shen et al. (2008) also reported a case of using AMT to detect hydrothermal breccia and mineralization alteration zones. The Shaxi porphyry copper deposit is a typical hydrothermal deposit with several NNE trending ore bands and the ore-bearing rocks mainly came from intrusive quartz diorite porphyries. A high-precision magnetic survey and a IP survey have been carried out in this mining area (Yang et al., 2002). While the shallow source magnetic anomalies well correlate to the known ore bodies, these surveys cannot identify deep ore bodies due to the limited sounding depth and strong pyritization. To investigate the shape and spatial distribution of quartz diorite porphyries, an AMT survey was conducted in this mining area. Based on AMT data, a 3D resistivity model of quartz diorite porphyry was constructed and this detailed 3D model will provide valuable information for future prospecting in and around this mining area.

**Geological setting**

Situated at the Northwest margin of the Luzong cretaceous volcanic basin, Shaxi porphyry copper deposit belongs to Middle-Lower Yangtze River metallogenetic belt. To the west, this mining area is bounded by the main fault of the Tancheng-Lujiang fault belt (Chang et al., 1991, Ren et al., 1991). Closely related to the Yanshanian (J-K) large-scale magmatism in the eastern part of China, these rocks and structure (anticline) are main factors that control the forming of these ore bodies. Figure 1 shows the location and structure map of the Shaxi porphyry copper deposit. The volcanic rocks of early Cretaceous are mainly trachy lava and pyroclastic rock of Yangwan group, distributed mainly in the northwest of the mine area. Silurian strata to the east are mainly sandstones and argillaceous siltstone. These host rocks are about 250 m thick and form an NE trending anticline. At the core of anticline, these strata are almost upright and the axial plane is dipping to southeast with an angle of more than 60°. Jurassic sandstone strata mainly located to the northwest and is close to 600 m thick.