Refining the understanding of the mineral system using deep geoelectrical data

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The mineral system views ore deposits as small-scale expressions of a range of earth processes that take place at different temporal and spatial scales. It was defined as all geologic factors that control the generation and preservation of mineral deposits (Wyborn et al., 1994). In its earliest iterations, the mineral system approach mimicked that of the petroleum industry and geothermal system, but now it is widely used in different mineral systems including magmatic Ni-Cu-PGE sulphide deposits, the gold mineral system and the other deposits (McCuaig et al., 2010; Barnes et al., 2016; Dentith et al., 2018). Data from different scales such as lithospheric-scale, regional-scale, mine-and camp-scale, were used for mineral system construction (Blewett et al, 2010). Geo-electrical, gravity and magnetic method plays a critical role in obtaining those data.

Most mineral deposits generally have higher conductivity than their host rocks, because of properties of the conductivity of metal ores. Besides, most of the mineral deposits relate to faults where fluids and debris act as electrical conductors. This makes mineral systems an ideal targets for the application of EM methods. Two EM approaches based on the natural EM field around the Earth as a source, namely magnetotelluric (MT) and audio magnetotelluric (AMT), are widely applied in mineral exploration. The MT and AMT methodd provide useful information about lateral and vertical resistivity variations in the subsurface. MT has a depth of exploration ranging from tens of meters to more than 10 km, which provides key data on regional- and mine-scales for mineral system analysis. MT data from a large extension and of very long periods could also be used for lithospheric-scale analysis. In contrast, AMT has a frequency range of 10-10 kHz, it has a relative shallow exploration depth and is commonly applied for evaluating the target with a depth of less than 1000 m, which serves on a mine-and camp-scale. Data from AMT have relatively high resolution whereas those from MT have deeper penetration depth, which provides deep geoelectrical data in the mineral system approach.

In practical operations, apart from geothermal explorations, most of the mineral explorations conduct AMT or control source AMT (CSAMT) and some other geoelectrical methods, such as TEM, DC electrical, SIP, which are characterized by relatively shallow penetration depth. As a result, detailed information up to some 1000 m about a mineral deposit are always acquired. These data are qualified in delineating a concealed deposit and to locate the drilling borehole. However, they are nit suitable for a comprehensive understanding of the mineral system, which consists of a favorable geodynamic setting, sources of fluids, drivers of fluid flow, fluid-flow pathways, metal transport-depositional processes, the preservation of the resulting deposit, and even a favorable lithospheric architecture (Dentith et al., 2018). In order to refine the understanding of the mineral system, data from deep geoelectrical EM methods are always employed for mineral system analysis.

We carried out several mineral system analyses using AMT and MT. One case history in the ZG mining area, southern Tibet, is shown in this abstract. A comprehensive geophysical exploration using AMT magnetic was carried out over a 32 km^2 area in 2014 and 2015. More than 30 sets of PMT (a kind of AMT receiver designed and produced by Champion Geophysics, Changsha, China) multi-channel AMT receivers were used for data acquisition. An electromagnetic array profiling (EMAP) with a low-pass filter were used to diminish or remove the topographic and static shift effects in the spatial domains. The filter result was converted by Bostick inversion. The three-dimensional geo-electrical structure was imaged from the result of 1300 AMT stations with a grid spacing of 80×20 m. The section of AMT (Figure 1) provided detailed resistivity variation along the profile which reflect the variation of the strata, structure and lithology. Three boreholes proposed by these data were drilled, and one of these intersected antimony ore with an apparent thickness of 1m in grade of more than 30 percent.

Understanding the mineral system based on the data from high density AMT in this area still remains puzzling even we have drilled the deposit. It is hard to answer where and how the deposit formed and whether there lies some other greater deposit deep in this area with elevation of less than 3500 m. Additional exploration using MT was conducted in two sections in the ZG mining area in 2016. This time we obtained resistivity information in sections with a depth up to 15 km. The top portion of the conversion results are shown in Figure 2. This shows a very low resistivity anomaly which reflects the magmatic source which features as hot and even partially melted. The pathway with low resistivity clearly revealed the underlying relation between the source and the deposit. Data from AMT and MT provide geophysical evidence that help to refine the understanding of mineral system in the ZG mining area, southern Tibet.

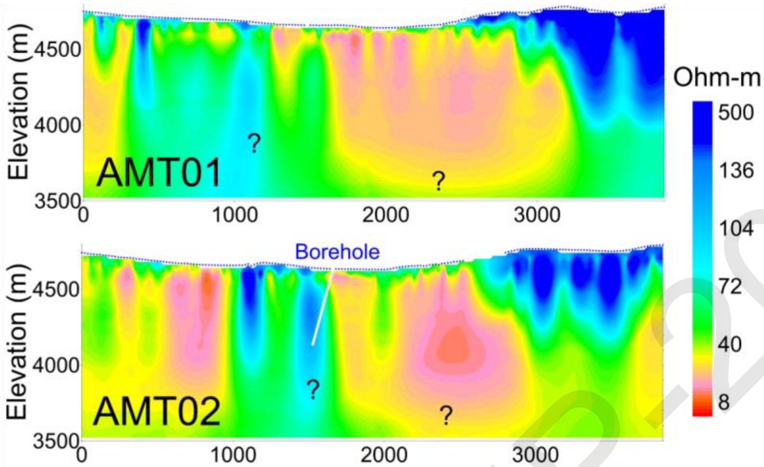

Figure 1. AMT convertion result shows the resistivity variation in Section 01 and 02.

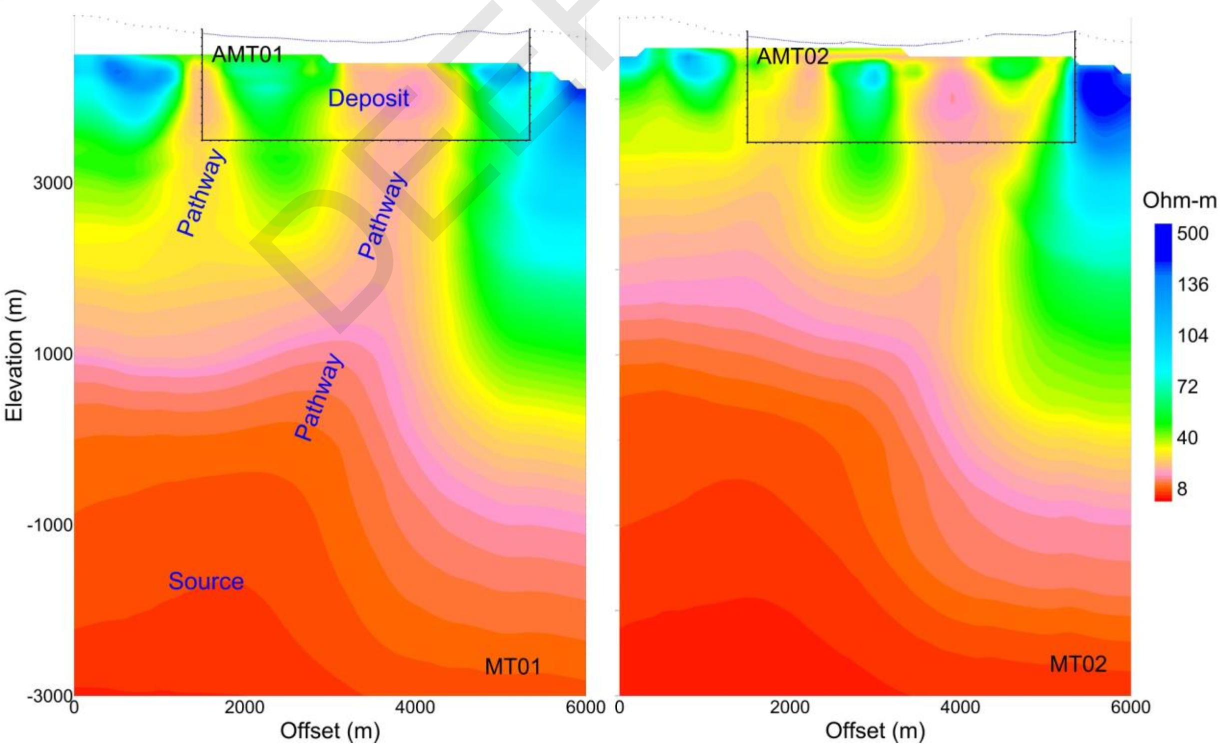

Figure 2. MT conversion result shows the resistivity variation in Section 01 and 02 with a depth of greater than 7 km. The source and pathway of the mineral system is reflected by very low and relative low resistivity in the sections.

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