The Application of AMT Based on 3D Modelling Technology in Uranium Exploration in Huayangchuan Area, Shaanxi Province

Li Bo*, Liu Kuanhong, Yao Huiming, Tu Hong
Eryisi Brigade Company Limited in Sino Shaanxi Nuclear Industry Group, Shaanxi Xian 710000

*Corresponding author’s email: 61772046@qq.com

Abstract. The AMT (Audio-frequency Magnetotellurics) has been carried out in the exploration of uranium deposits in Huayangchuan area, Shaanxi Province. The results show that AMT can effectively detect the scale and occurrence of tectonic fractured zones. It provides an effective technical methods for the uranium deposits in Huayangchuan area to search for deep and peripheral exploration.

Keywords. AMT, uranium deposit, deep prospecting

1. Introduction
The hard rock type uranium deposits in Huayangchuan area of Shaanxi Province are located in the Xiaoqinling structural belt where the North China plate contacts the Qinling orogenic belt. Since it was discovered in 1957, most of the shallow and large-scale uranium deposits have been exposed. At present, the focus of the work is mainly to carry out the expanded exploration around the discovered uranium deposits, and at the same time to explore the deep part of the deposits [1]. Because the deposit has the characteristics of "large scale and low grade" [2], it is difficult for the radioactive geophysical prospecting method used in conventional uranium exploration to play an ideal effect in this area [3]. Hard rock type uranium deposits are closely related to structural faults, rock masses, vein bodies, etc. uranium ore bodies often occur in large-scale structural fracture zones [4]. In order to find out the scale and occurrence of the large-scale structural fracture zone closely related to uranium mineralization, as well as the distribution characteristics of the rock masses on both sides, we can only rely on conventional geophysical methods such as gravity, magnetic method, electromagnetic method and earthquake, especially the geophysical methods of sounding.

2. Geological and geophysical characteristics of the working area

2.1 Geological characteristics
The strata related to uranium mineralization in the working area are mainly Taihua Group, which are mostly xenoliths or stratigraphic fragments scattered in the vArchean grey gneiss series widely distributed in the area. The lithology is mainly quartzite, quartz schist, marble and other metamorphic supracrustal rocks. The overall distribution of Taihua Group is consistent with the direction of regional structure, showing a northwest direction. The main fault structure related to uranium mineralization is Huayangchuan fault zone, which is a broad brittle ductile fault zone in this area, with secondary faults developed, forming a NW-SE fault zone with dense fractures,
which are mostly filled by different types of vein rocks and ore veins. The exposed magmatic rocks include Archean metamorphic intrusive rock, Proterozoic Xiaohe rock mass, Cretaceous Jurassic Huashan rock mass, Laoniusan rock mass and various vein rocks.

2.2 Geophysical characteristics
In this work, the first resistivity statistics of all AMT measuring points are carried out. According to the previous physical property data of the working area and the first resistivity statistical results of all AMT measuring points, the main rock electrical model of the working area is obtained. The Quaternary sediments and gneiss show relatively low resistance. The monzogranite body shows relatively high resistance. According to the comprehensive analysis of the physical parameter data of this work and the previous geological data and physical parameter data of the work area, it is concluded that the apparent resistivity of the structural fracture zone in the work area is not more than 5000 $\Omega \cdot m$, and that of the surrounding rock is more than 5000 $\Omega \cdot m$.

3. Method application
Three AMT sections (Z1, Z2 and Z3) are arranged respectively from north to south in the working area, and the positions of three sections coincide with the positions of known geological sections, and have passed through the proven uranium ore bodies. The purpose of the experiment is to explore the scale, occurrence and the distribution of rock mass on both sides of the structural fracture zone.

In this field data acquisition work, the instruments used for AMT measurement are mtu-5a and mtu-2ea magnetotelluric instruments which produced by Phoenix Company of Canada, with the working frequency of 1Hz-10$^4$Hz. In order to accurately reflect the occurrence of large-scale structural fracture zone, five components are collected in the data acquisition work. The acquisition parameters determined by field acquisition test are: data acquisition time is 60 minutes, the distance between measuring electrodes is 30 meters, and the distance between measuring points is 50 meters. In the process of actual data collection, in order to avoid the human interference brought by the high-voltage line, highway and residential area on the side of highway to the greatest extent, the observation points close to the high-voltage line, highway and residential area adopt the two-component observation of electric channel, the three components of the magnetic track are selected for synchronous observation and the data far away from the high-voltage line are used to reduce the impact of human interference on the data quality. In the process of data processing, far reference and cross reference technology are used to remove noise. This AMT data processing mainly uses ssmt2000 data preprocessing software and winglink inversion software, and the inversion method is nonlinear conjugate gradient method. Cai Juntao et al [5]. Found that when two-dimensional inversion is carried out for the magnetotelluric sounding data generated by the three-dimensional model, the data of TE mode is very vulnerable to the effect of distortion of three-dimensional electrical anomalies, and the approximation degree of TE mode to the two-dimensional model is much higher than that of TM mode. In contrast, TM model data is less affected by three-dimensional distortion effect, which can more accurately reflect the geometry of electrical body distribution along the profile direction, and is more suitable for two-dimensional inversion. In addition, TM mode is better than TE mode in identifying high resistivity body in underground medium. When te model data is seriously affected by three-dimensional abnormal body, TM model or TM + Hz model data are usually used for two-dimensional inversion.

Some studies have shown that the vertical magnetic field component is used to reflect the transverse change of the conductivity of underground media [6], and can effectively reflect the structural characteristics of faults and fracture zones [7]. There is a comparison between the inversion results of AMT profile and geological profile of line A. The inversion results of TM+Hz model, compared with the inversion results of TM model in the figure, not only reflect the location and scale of ore bearing structural fracture zone, but also accurately reflect its occurrence. This shows that the data of Hz model plays an important role in constraining the occurrence of structural fracture zone in inversion model. In conclusion, TM+Hz inversion results are determined as the final inversion results of three AMT profiles.
Figure 1. 3D display of AMT 2D inversion results of Z1, Z2 and Z3 lines

The results of 2D inversion of Z1, Z2 and Z3 AMT lines (Figure 1) show that the structural fracture zone is located in one uranium metallogenic belt, and the position of the structural fracture zone reflected by the three sections coincides with the position of the proved uranium ore body, which shows that AMT method has good application effect in this area.

4. Conclusion
AMT method can accurately detect the scale and occurrence of structural fracture zone, the scale and fracture tendency of rock masses on both sides in Huayangchuan hard rock area. AMT method can solve the geological problems of blind deep exploration and peripheral exploration of hard rock type uranium deposits in Huayangchuan area, and provide a powerful technical method for a new round of uranium exploration in Huayangchuan area. The results of this study show that the vertical component Hz of the magnetic field has obvious effect on restraining the occurrence of the structural fracture zone. It is suggested that the five component measurement should be used to carry out AMT work in Huayangchuan, an area with complex geological characteristics, in order to obtain more accurate geophysical results.

5. References
[1] Li Q, Wang J P, Xu Q Y. 2003 General situation and prospect on supply and demand trend of the world uranium resources vol 22 no 11 (China Min Mag) pp 13-18.
[2] Xue S, Xu Y, Li M X, et al. 2018 Geochemical constraints on genesis of Paleoproterozoic A-type granite in the south margin of North China Craton (Lithos) pp 489-500.
[3] Chen k, Yang Z Y, Zhou R H, et al. 2018 The ground gamma energy spectrum in Aerbulage area and its relationship with uranium mineralization vol 42 no 4 (Geophysical and Geochemical Exploration) pp 703–707.
[4] Kong Z Z, Wu Y. 2016 A discussion on some EH-4 measurement problems in hard-rock areas in southern China: A case study of the Shazijiang deposit vol 40 no 4 (Geophysical and Geochemical Exploration) pp 804–808.
[5] Cai J T, Chen X B. 2010 Refined techniques for data processing and two-dimensional inversion in magnetotelluric Ⅱvol 53 no 11 (Chinese J. Geophys) pp 2703-2714.
[6] Parkinson W. 1959 Directions of rapid geomagnetic fluctuations vol 1 (Geophys. J. R. Astr. Soc) pp 1-14.
[7] Tian Y, Hu X Y, Le B. 2018 The application of tipper to geophysical fault interpretation vol 42 no 6 (Geophysical and Geochemical Exploration) pp 1237-1244.