EH4 Electromagnetic Imaging System and Its Application in Gold Ore Exploration

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Abstract. EH4 electromagnetic imaging system is relatively advanced electromagnetic exploration instrument at home and abroad with the advantage of great exploration depth, intuitive and portable etc. In this paper, on the basis of the systematical collection of predecessors’ research data and combined with the present situation of domestic and foreign researches, the author introduces the working principle of the EH4 electromagnetic imaging system, field-working method, scope, and possibly, and some geological problems that may be solved in gold prospecting. Apart from this, through exploration cases of in Zhashangou Gold mining in Heilongjiang province, Yuerya gold deposit in Hebei province and in 460 gold mine in region of Beishan of Gansu, this paper illustrates that the effect of EH4 system in gold deposit exploration is remarkable which is an significant geophysical exploration method to be promoted.

Keywords: EH4 electromagnetic imaging system, Electrical survey, Gold ore exploration, Application effect

1 EH4 electromagnetic imaging system introduction

EH4 electromagnetic imaging system (“EH4” for short) is a magnetotelluric measurement system co-developed by the Geometrics and EMI in 1996. It combines the natural electromagnetic field and artificial electromagnetic field, which becomes the organic combination of MT and CSAMT. Taking differences between the electrical conductivity and magnetic conductivity of different rocks as physical basis, EH4 gets the apparent resistivity images of underground two-dimensional profile through measurement in continuous lattice and then conjecture the underground structures and distribution status of rock based on this.
2 EH4 system working principle

EH4 system realizes the probing of electrical resistivity or conductivity of sounding mainly through transmitting and receiving electromagnetic waves from the ground. The continuous probing lattice forms the underground two dimensional resistivity profiles and even some three-dimensional resistivity imaging. The basic parameters of observation can be seemed as the two orthogonal electric field components (Ex, Ey) and two magnetic field components (Hx, Hy) and thus the apparent resistivity of two different directions can be obtained from parameters of the above observations, and then calculate tensor impedance to acquire the stratal resistivity value[1-2].

Based on the magnetotelluric theory based on Maxwell equations:

\[ Z = \sqrt{\frac{\mu}{\rho f (1 - i)}} \]  \hspace{1cm} (1)

In the above formula, \( f \) refers to frequency, \( \mu \) refers to magnetic conductivity and the formula (1) can be used for the determination of telluric resistivity.

\[ \rho = \frac{1}{5f} \left| \frac{E}{H} \right|^2 \]  \hspace{1cm} (2)

In the above formula, unit of \( \rho \) is \( \Omega \cdot m \), unit of \( E \) is \( mv/km \) and unit of \( H \) is \( nT \).

The above expression can still be applied into the horizontal layered earth. However, the resistivity calculated through it shall be seemed as the apparent resistivity, and it would varies with frequency since there is a relation between the ground penetration of the electromagnetic wave or skin depth and the frequency, which can be showed as follows:

\[ \delta = \sqrt{\frac{2}{\omega \mu \sigma}} \approx 500 \frac{\rho}{\sqrt{f}} \]  \hspace{1cm} (3)

In the above formula, unit of \( \delta \) is m.

Though, at one level, there is some relation between the skin depth and the penetration depth of the electromagnetic wave in the medium; however, it does not represent the actual effective detecting depth. The actual effective detecting depth refers to the average volume detection depth of some sounding method and the empirical formula towards this is as follows:

\[ D = \frac{\delta}{\sqrt{2}} \approx 356 \approx \frac{\rho}{\sqrt{f}} \text{ (m)} \]  \hspace{1cm} (4)

It can be illustrated from the above formula that penetration depth can only depends on the earth resistivity and signal frequency employed. Penetration depth becomes smaller along with the decrease of the resistivity or the increase of frequency; on the contrary, penetration depth becomes larger along with the increase of the resistivity or the decrease of frequency. If the earth resistivity structure is constant, continuous vertical sounding can be reached through the
change of the signal frequency, and this is the basic operation principle of magnetotelluric method.

3 Application sphere of EH4

Application scope of EH4 magnetotelluric includes two aspects: the scope of observation method and the observing object. In fact, application of observation method is mainly determined by different objects and thus both of them belong to the application scope of observing objects [6].

3.1 Application scope of observing methods

EH4 observation method is the end-to-end profile observation way which means the end-to-end of measuring point between electrodes and then makes the continuous observation, through which the geoelectric characteristics below the measuring line can be reflected and static effect can thus be suppressed to the largest extent. When choosing the observation way, it should better choose the end-to-end profile observation method and if it cannot meet the conditions, the side line and horizontal line shall be considered based on the comprehensive research of factors including goal and the cost efficiency. The reducing of static effect and the terrain effect should be fully given attention when the discontinuous section observation method should be applied.

3.2 Application scope of observing objects

Magnetotelluric observation object can be generally divided into low resistance in high resistance states, high resistance in high resistance states, low resistance in low resistance states and high resistance in low resistance states. It is rather difficult for the exploration of relatively high resistance body; no matter it is the high resistance body exploration in high resistivity zone or the low resistivity zone. The resolving power of low resistance body is highly dependent on the ratio of low resistance body relative to the surrounding rock resistivity. Therefore, towards the low resistance in high resistance states, the resolution ratio is rather high with the application of electromagnetic method, but the resolution ratio is rather low as to the low resistance in low resistance states with low resistivity ratio. Thus we should pay attention to the following points when using this method:

(1) As to the magnetotelluric EH4, enough electrical conductivity difference or in other words, finding an enough low resistance in an enough high resistance is the premise of acquiring the accurate resolution as precisely as possible. However, it is difficult to find high resistance in low resistance state, whatever the difference it is.
(2) Deep abnormal should be determined reliable than the shallow, of which the depth should at least more than 100m. This is not only because the shallow electrical differences is not large enough, but also holds some relations with the point density of high frequency part and noise interference and other factors. Of course, if increase the emission sources in the high frequency part of the, the effect in the shallow part shall be improved, which undoubtedly improves the signal-to-noise ratio and increases the density of the trusted frequency point. However, whether the signal strength increase would help to improve the resolution is still a question.

(3) Even got enough resolution, EH4 electromagnetic is still unable to accurately determine the problems like fault width and it still depends on the synergy of other geophysical techniques to make the identification. In fact, the practical problems is far more complex and a lot of work need to be done as to the further understanding of the related problems including theoretical and practical levels.

4 Problems

Although the application fields of EH4 electromagnetic imaging system has extended to all aspects in solid mineral, oil gas and water exploration, engineering exploration, environment monitoring and geoscience basic theory research and etc. [14-20], as one of the earth electromagnetic technology, EH4 also exists some common problems of magnetotelluric method and limited by the electromagnetic method itself.

In terms of data collection, terrain factors had a large influence towards the using effect of EH4 and the electrical interface occurrence obtained shall cause division at the rugged terrain [9]. Although in the continuous observation section, spatial filtering techniques of Bostic-inversion can be applied during the inversion process and thus weakened to some extent, the impact is much obvious when discontinuously observing the measuring point. As to the observation object, EH4 electromagnetic imaging system also has limitations. Enough electrical conductivity difference or in other word, finding an enough low resistance in a enough high resistance is the premise of acquiring the accurate resolution as precisely as possible and deep abnormal is more reliable than the shallow abnormal. Apart from this, the method to suppress abnormal shallow is still need further exploration.

References