

Transient Electromagnetic Method and Its Applications in China

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Introduction

Transient Electromagnetic Method (TEM) is a time-domain electromagnetic method. There are two main survey configurations: one is loop-source configuration; another is grounded source. Loop-source TEM is a kind of special configuration, which lays a large square loop to excite a square wave current and energize a primary field. The induction voltage of transient magnetic field is measured with a small loop or a receiver magnetic antenna in a defined range situation inside of square loop. Because the transmitter loop keep relatively fixed, the field nearly keep even and stable in some range inside loop. We can get reliable results. Grounded-source TEM lays a grounded wire to excite a step-off current and energize into the ground, which is different from the loop source. The induction voltage or electric field is observed with a magnetic core or grounded short wire. Compared to loop-source TEM, the grounded one has larger detecting depth.

TEM has many advantages, such as:

- (1) There is one transmitting device accompanied with two or more acquiring machines for loop-source or grounded source TEM, which can be used on various surveying conditions
- (2) TEM observed only secondary field, which is separated from primary field
- (3) TEM has small volume, especially for loop source
- (4) TEM has high penetrability to high-resistivity medium and high resolution for low-resistivity medium
- (5) TEM is not sensitive to the topography and can observe in near-field zone.

Applications in China

TEM is widely used in hydrogeology, oil and borehole data study, sea investigation resource exploration, engineering studies, disaster surveys, water conservation, etc.

Application in ore deposit investigation in complex condition

China is a mountainous country and there are enriched ore behind mountains, which is not easy for geophysical method to work here, especially for 3D seismic exploration. Seismic method is not suitable for desert area, while TEM is economic and efficient for it. Besides, ground-well TEM is used more comprehensive.

Application in coal mine exploration

China is the largest country of coal production and consumption. With the fast development of China's economy, energy is required enormously. In the meantime, some severe problems have appeared, such as resource exhaustion, geological disaster, destruction of water resources and deteriorative eco-environment, among which the surface sinking and houses collapsing are common. Moreover, the deformation and failure caused by coal mined-out voids can directly lead to ground cracks and landslides. Therefore, it is of great significance to rapidly detect the mined-out area and its range.

Central-loop TEM configuration is now increasingly used for coal mining generally in China. It is sensitive to anomalies of geological

structures with low resistivity, and is relatively easy to implement in complex working conditions, and therefore commonly used to probe water-rich geological bodies.

Application in tunnel prediction

It is a well-known fact that in the west-south of China, there are large numbers of mountains which lead to low economy development in the area, therefore, constructing railway is one of the most important tasks for government and designing a lot of tunnels is a good choice for railway construction. But the geological structure is very complex in the area. So, it is crucial to carry out tunnel prediction before excavation.

Tunnel prediction based on geology is mainly attained through the combination of drill exploration, and geophysical methods including Tunnel Seismic Prediction, True Reflection Tomography (TRT) and etc. However, there is no efficient way to detect water-filled geological features during tunnel based on geology prediction. Compared with traditional drilling survey, the TEM is fast and efficient, and gives a clear image in the detection of a complex geological structure. Therefore, it is not only feasible but also necessary to use TEM for survey of complex underground caves in highway and railway constructions.

In China, firstly over the country, we introduce the working configuration of TEM tunnel prediction. Small central loop configuration and special antenna, which be used to get rid of the signals come from the back of tunnel, have been used in tunnel. TEM response is sensitive to conductance bodies and the received signal corresponding to the peak of the secondary field can provide useful information about the target.

Other applications in engineering geophysics

TEM is also used in hydrogeology and environment engineering, such as geological hidden troubles of high-rise buildings, nuclear power station, water power station, highway and bridge. It is also potential for TEM to be used in building lossless monitoring, water source development, railway construction, sea water intrusion, ground precipitation and prediction of geologic hazards.

Advance Development of TEM in China

Theory study

At present, there are several leading topics about TEM theories: 2D and 3D forward and inverse under complex circumstances; high-

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resolution imaging of TEM sounding; multi-component TEM data interpretation; pseudo-seismic multiple-coverage method and MTEM. In addition, it is crucial research for TEM survey to separate useful signal from noise under strong interference and extract weak signal at late time stage.

Method and techniques test

Pseudo-seismic multiple-coverage data collection is important for deep exploration of resource and fine survey of engineering. In

addition, multiple-component detecting and MTEM can enrich our geo-electric information, which attracts researchers' attention.

Instrument development

It is the modern development for geophysical researchers to manufacture multiple-component, multiple-channel TEM observing system, which is high-power, multifunction, intelligent and suitable for MTEM. Furthermore, it is also important for researchers to develop high-sensitivity, three-component probe.