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# Investigation of Ye\_cheng Site of China using geophysical archaeology technology

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**Abstract:** The main object is to identify the position of rammed earth site using geophysical technology. Firstly, geophysical investigation was finished in known area where culture relics and their positions are known. And the known position information was obtained using drilling and exaction before. Secondly, the effective geophysical technologies were selected through comparison between geophysical exploration results and drilling and exaction data in the known area. At last, the geophysical technologies were used in unknown area and the culture relic positions were inferred using geophysical image. The results show that horizontal positions of ancient construction base and road can be discerned from magnetic and ground electromagnetic method (GEM2) image. But the exploration precision of GEM2 is lower than that of magnetic method. The depth can be found using ground penetration radar (GPR) phase attribute. It is concluded that geophysical technology is effective for investigating rammed earth construction base and ancient road. The space position of culture relics can be identified by combination application of magnetic and GPR.

**Key words:** Geophysical technology, ancient site investigation, Ye\_cheng site

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## 1 INTRODUCTION

There are many physical property differences such as magnetism, density, electrical property and so on between subsurface culture relics and surroundings. Through geophysical technology, the physical property parameter distribution image of subsurface medium can be acquired. Based on the above differences between culture relics and surroundings and combined with archaeology data, the position of culture relics can be inferred by analyzing physical property parameter image of subsurface medium. Compared with traditional archaeological investigation methods such as drilling, geophysical archaeology technology has non-destructive, quick and low-cost advantages. Then geophysical archaeology technology is increasingly used to investigate sites (David, 2009; Christian, 2010; Urs Böniger, 2010). Especially in Europe, geophysical technology has been accepted by archaeologists and is a main archaeological investigation method. However, geophysical technology hasn't been accepted by archaeologists in China. The main

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reason is that geophysical detect effect is restricted due to the minimum physical property differences between culture relics and surroundings. In order to examine validity of geophysical archaeology technology and then to extend its application in Ye\_cheng Site in the future, an application test was finished in North Dynasty Temple site at Zhao\_peng\_cheng village in 2012.

## 2 Field site

Ye\_cheng Site lies in the Lin\_zhang County of He\_bei Province of China and is the National Key Unit of Cultural Heritage Protection. Especially, the North Dynasty Temple discovered in 2002 at the Zhao\_peng\_cheng village in the Lin\_zhang County is an important discovery in Ye\_cheng site. Inferred from culture relics acquired by excavation, the prominent position in ancient city and novel construction technology indicate that the Temple site has a significant meaning in Buddhism archaeology. Some ancient construction base positions have been found using drilling and excavation. The plan of some ancient construction bases is shown in Figure 1. However, the local archaeology investigation finished using drilling and excavation restricts comprehensive understanding of the North Dynasty Temple. The detail investigation is needed to understand ancient site distribution.

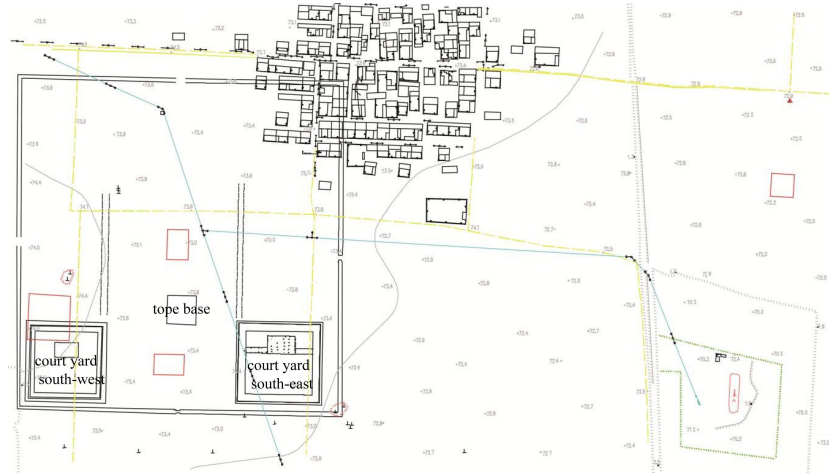


Fig. 1 Ancient site position plot of the North Dynasty Temple

## 3 Geophysical data acquisition and processing

Magnetics, ground electric magnetic (GEM2) and ground penetration radar (GPR) were tested in the known area. Line interval and point interval of magnetic data acquisition was 0.5m and 0.1m respectively. Line interval and point interval of GEM2 data acquisition was 0.5m and 0.2m respectively. And line interval and point interval of GPR data acquisition was 0.25m and 0.1m respectively. Then geophysical data were processed. Data processing methods of magnetic mainly included high-pass filter, diurnal variation correction and analysis signal computation. The filter and inversion processing methods were used to process GEM2 data. And GPR data was processed using band-pass filter, amplitude compensation, background noise suppression and attribute computation.

## 4 Results

The result of magnetic and GEM2 in the west of temple site are shown respectively in Figure 2. From Figure 2, a magnetic anomaly along west-east orientation can be seen obviously. And the position of anomaly is consistent with ancient wall site. So the anomaly is the response of ancient wall. From Figure 2, the GEM2 response is obvious in the

ancient wall position. However, the resolution of GEM2 is lower than magnetic method. Two GPR instant phase attribute profiles along north-south orientation are shown in Figure 3. From Figure 3, the reflection from top of ancient wall base can be seen and the depth is 1.1m. The results show that ancient wall constructed with rammed earth can be found using magnetic, GEM2 and GPR.

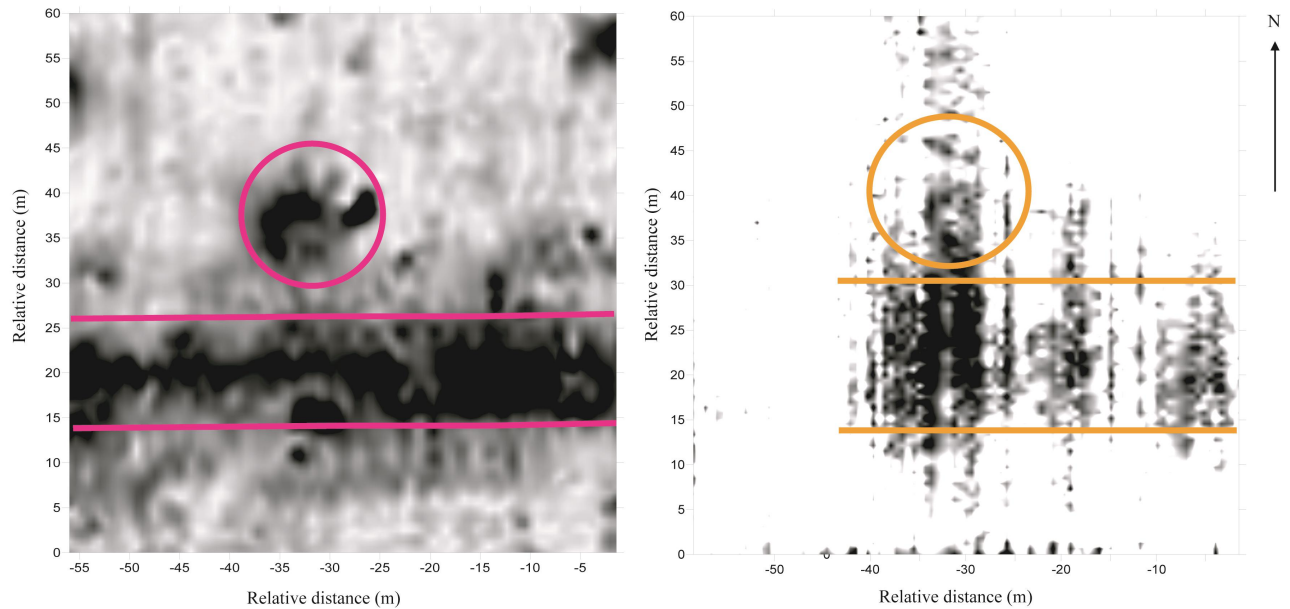


Fig. 2 Magnetic (left) and GEM2 (right) results from area in the west of tope base

The results of magnetic and GEM2 in the north of temple site are shown in Figure 4. A magnetic anomaly along north-south orientation can be seen in Figure 4. This anomaly is the response of ancient road. There is a rectangle magnetic anomaly in Figure 4. It is the response of ancient construction base. From GEM2 image, there is only the response of ancient road.

The results of magnetic and GEM2 in the south of temple site are shown in Figure 5. There is an anomaly along north-south orientation in the east of work area. Ancient road soil has been found using drilling. So the anomaly is the response of ancient road soil. Moreover, this anomaly can be seen in the GEM2 image.

In the east of temple site, there is a rammed soil site under the ground. However, the range is unknown. The detect results are shown in Figure 6. From Figure 6, there are some disorderly anomalies in the middle and left area. These anomalies are the response of ancient construction base. Moreover, there is a quadrate anomaly in the right area. It is probably the response of rammed soil site. However, there are only some high electric resistance anomalies in the GEM2 picture. The resolution of GEM2 results is lower than magnetic method.

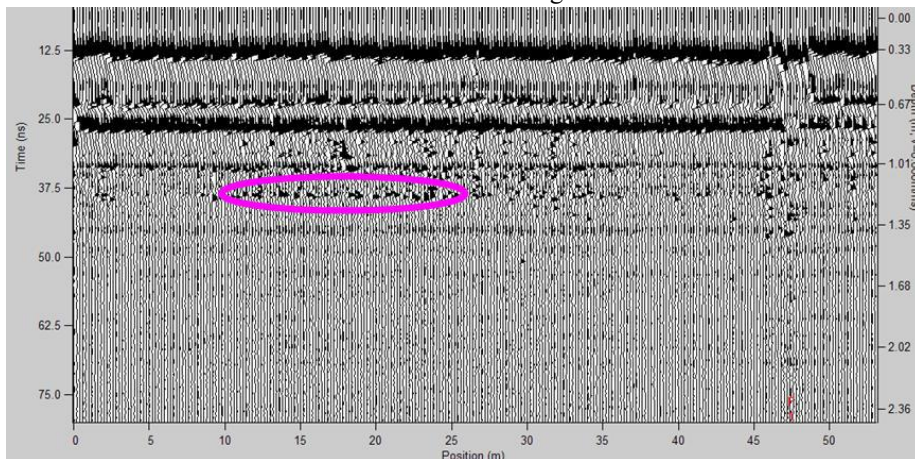


Fig.3 GPR result from area in the west of tope base

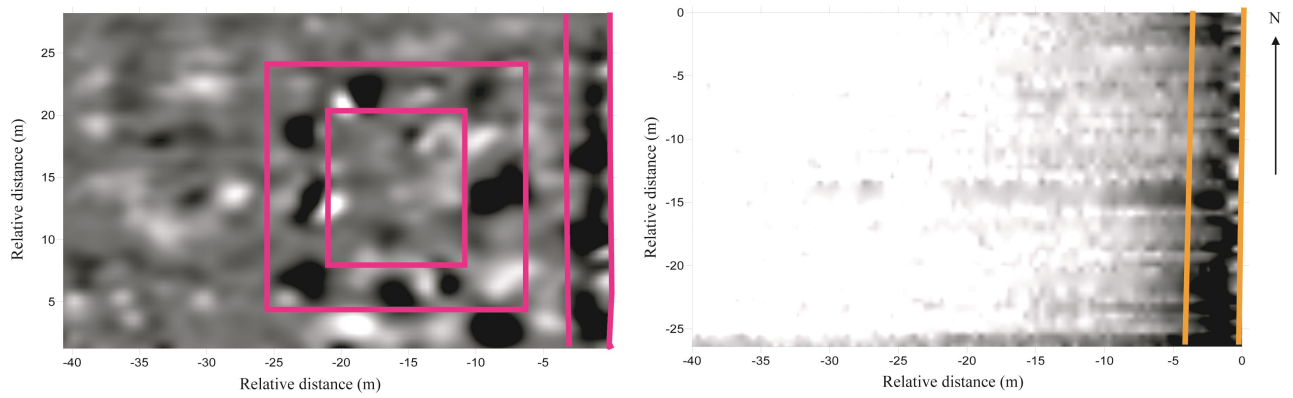


Fig.4 Magnetic (left) and GEM2 (right) results from area in the south of tope base

## 5 Conclusion and discussion

It is concluded that geophysical technology is effective for investigating rammed earth construction base and ancient road. Compared with GEM2, the effect of magnetic method is better when investigating the above culture relics. Through GPR, the depth of culture relics can be discerned. The space position of culture relics can be identified by combination application of magnetic and GPR.

Through geophysical investigation, the magnetic and electric attribute can be acquired. Based on geophysical results, the type of culture heritage underground can't be inferred directly. It is future direction to interpret geophysical image combining with some data from drilling and excavation.

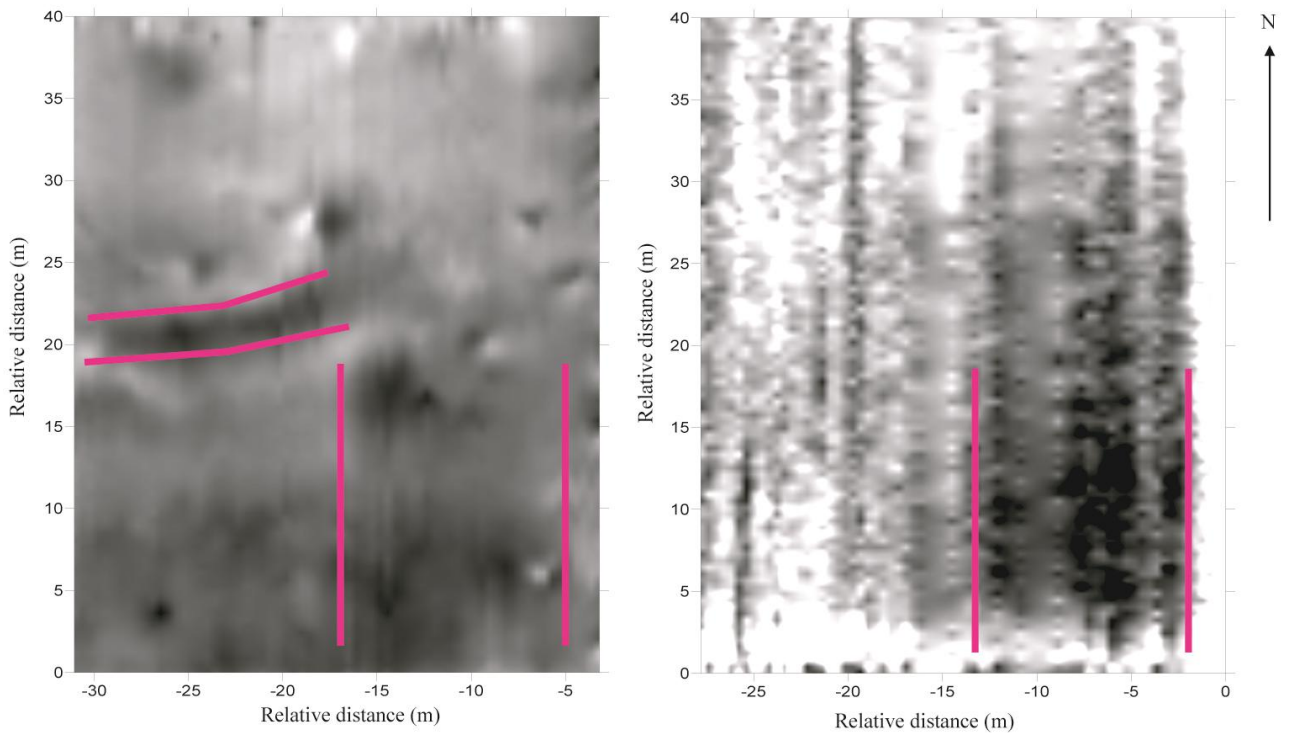


Fig.5 Magnetic (left) and GEM2 (right) results from area in the north of tope base

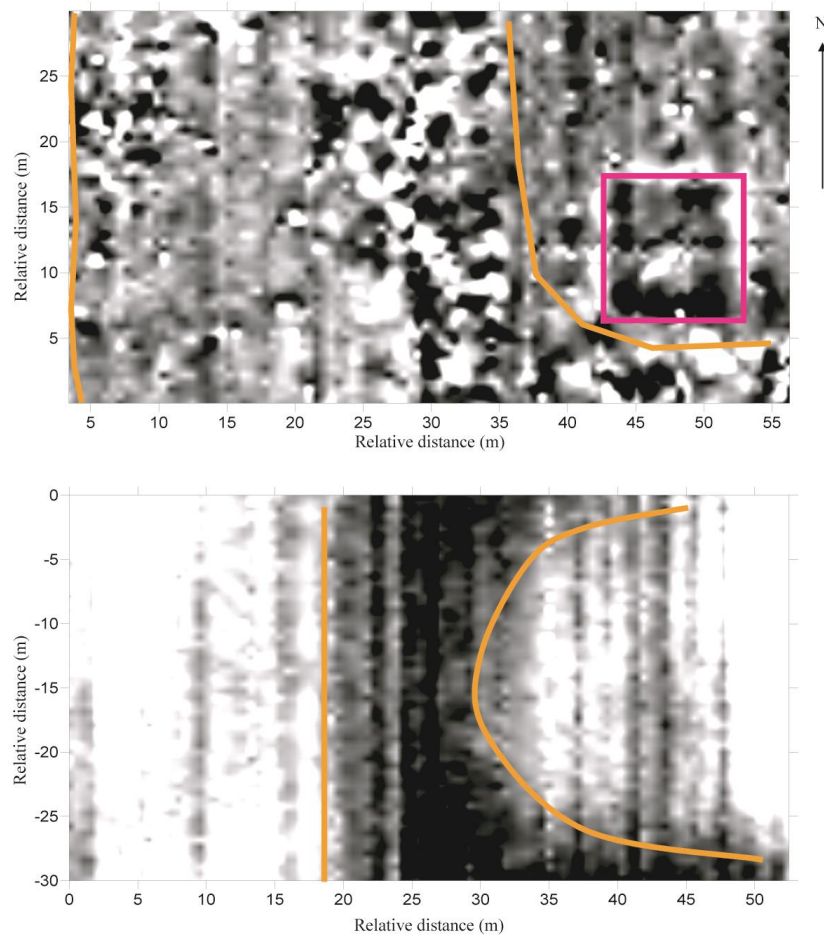


Fig.6 Magnetic (top) and GEM2 (bottom) results from area in the east of tope base

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