The Application of High-precision Magnetic Measurement in Underground Pollutants Detection

Hao Zhang, Jin Yang

School of Geophysics and Information Technology, China University of Geosciences, Beijing 100083, China

Abstract

Analyzing the magnetic anomaly distribution of surveyed area, detecting and analyzing the underground pollutants in this area, to offer evidence for this area's environment protection and groundwater pollution treatment. This paper takes advantage of the high-precision magnetic measurement's simple and high-efficient characteristics to survey an insidious refuse landfill in Beijing, adopts GSM-19T high precision proton magnetometer to explore and measure the eleven measuring lines in surveyed area, after the data processing, combines with local conditions to discuss the result of the detection. The result shows that the west influenced by a large area of barbed wire and underground utilities has appeared a big negative anomaly; the west of the gully is normal farmland which is abnormal low and smooth; the east of the gully influenced by the underground pollutants has appeared positive anomaly, the local anomaly value is bigger.

Keywords

High-precision magnetic measurement; Refuse landfill; Near-surface exploration.

1. Introduction

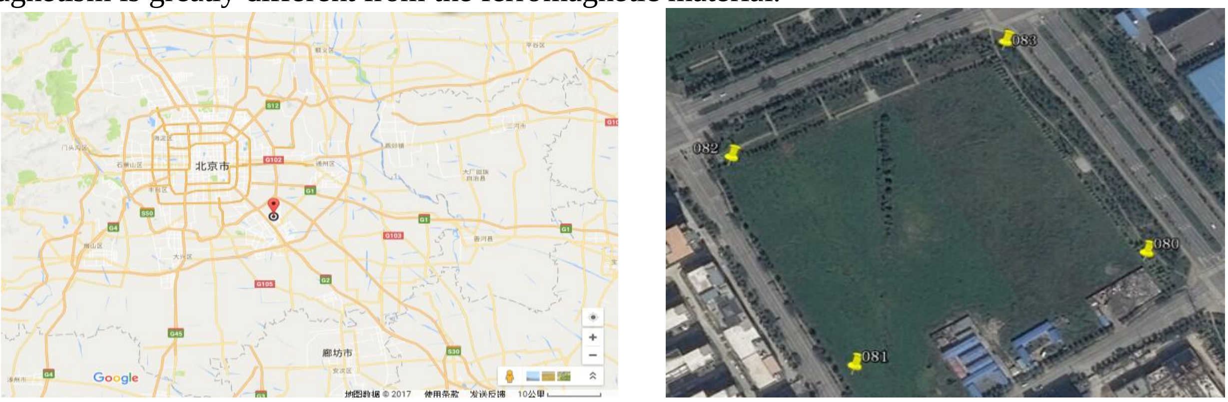
Environmental pollution is a global hot issue. Since the reform and opening up, with the accelerating pace of urbanization and industrialization, the output of solid wastes has increased rapidly, landfill method is an important mean to deal with the wastes. The existence of refuse landfill and its leachate leakage problem have a strong impact on human life and endangered the human living environment. So the detection of the refuse landfill has important practical significance.

Many experts and scholars at home and abroad have already carried out the research and application of high-precision magnetic measurement in underground pollutants and achieved a certain effect. Such as Yong-li Yan revealed the underground electrical property architectural feature of Asuwei refuse landfill in Beijing by magnetotelluric observation and research. It introduced a quantitative parameter of groundwater pollution level resolution through the theory of fuzzy mathematics' membership function. He distinguished the underground pollution status of Asuwei refuse landfill in detail, to mark off severe polluted area, mild polluted area, pollution critical area and unpolluted area. Cheng Yexun did examination to detect the diffusion scope and diffusion depth of waste effusion of two refuse landfill in Beijing, by using high density resistivity method, ground penetrating radar method, transient electromagnetic method, ground temperature method and so on, and got the result that polluted soil and underground water have presented low-resistance characteristic. Neng Changxin has researched the electrical properties of earth electricity physical model of refuse landfill, he pointed out the size of soil capacitance increased with the increase of test area and voltage. This paper takes advantage of high-precision magnetic measurement to investigate some area in Beijing, through the analysis of different exceptions to judge the relevant information of underground insidious refuse landfill, and to offer evidence for this area's environment protection and groundwater pollution treatment.

2. Survey region

This survey region is located in Daxing District of Beijing. Beijing is situated in the north of North China Plain, with the high terrain of the northwest and southeast low, the mountains in the north and west belong to Taihang Mountain and Yanshan Mountain. The urban area is located in the alluvial-proluvial plain leaning to southeast. Since Archaean, Beijing has experienced three geotectonic stages: the platform crystalline basement forming and development of pre-luliang period, platform cover development of after-luliang and indo-china period and Yanshan-Himalayan pacific continental margin activity. Its regional tectonic framework expresses the intersected and composite characteristic that early east-west of nearly east-west uplift depression or fold and rupture to the later north-east, north-north-east or nearly south-north trending fold and faults. On the geological structure, Daxing district landscape is mainly formed by Yongding River alluviation and sedimentation, it belongs to a part of Yongding River alluvial fan. Its quaternary strata is the unconsolidated sediments within 100 meters buried depth and is divided into three layers in vertical: the first layer's roof buried depth is 10-20 meters with the water layer, its lithology mainly contains sandstone, from coarse to fine, the thickness is about 5-10 meters, this layer is easily to be polluted, poor water quality. The second layer's roof buried depth is 20-30 meters, its lithology mainly contains sand pebble and sandy gravel, the thickness is 9-25 meters. The third layer's roof buried depth is 38-60 meters, thickness is 8-15 meters, its lithology mainly contains median-coarse gravel, and water gets small.

This survey region is an open area surrounded by city road, as shown in figure 1. It has a flat surface and is divided into two parts by the gully in the middle, mainly distributes some weeds and crops. Its magnetism is greatly different from the ferromagnetic material.



(a)Traffic position (b) field positon

Figure 1. Location plan of the survey region

3. Data acquisition and processing

The survey line is laid out from south to north, first to determine the southwest corner point as the basic point by the longitude and latitude coordinate (figure 1, 81 point), then according to the NW24° direction to determine the southwest main measuring edge (ligature 81-82), the length is 250 meters, line distance is 25 meters, so on the main measuring edge, eleven measuring line origin are formed from south to north; the measuring line perpendiculars to the main measuring edge, its length is also 250 meters, so there are eleven measuring lines as shown in the following figure, and form a measuring net with 250 meters in length and 250 meters in width eventually (limited by site condition, the actual lengths of the two lines on the northernmost side are 115 meters and 235 meters), as shown in figure 2, the measuring dot pitch is five meters. To determine the southernmost measuring line as 100 line, the line number increases at 25, so the northernmost measuring line is 350 line.

Figure 2 Arrangement plan of the measuring lines

Selecting four GSM-19T high precision proton magnetometers for field work, three for grouping measure and one for daily variation observation.

Figure 3 GSM-19T high precision proton magnetometer

Measurement range：10000-120000nT
Measurement accuracy：±0.2nT
Sensitivity：<0.05nT
Resolution ratio：0.01nT
Sampling rate：3-60 second
Gradient tolerance：>7000nT/m
Main engine：223×69×240mm
Sensor：170mm (length) ×75mm (diameter)
Temperature range：-40℃ to +55℃

In order to achieve a better treatment effect, this time the high precision magnetic survey uses the combination of two sets of soft wares: GEMLinkW 3.0 and Model Vision 9.0. In order to guarantee the accuracy of data and easy to interpret comprehensively, we deal with the collected data from field as following: daily variation correction, altitude correction, data gridding, pole change, upward continuation and so on. Combined with the local conditions and data processing result, we use the plane contour map of the magnetic anomaly which is extended upward for three meters to do explanation (see the following part, result and discussion).

4. Result and discussion

According to the result of data processing, we divide the abnormal area into eight regions from A to H, as shown in figure 4. Combined with the field environment, we divide these eight regions into three kinds: the first kind is negative anomaly kind, which is A anomaly region, as can be seen from the figure, it presents the color of blue; the second kind is low value anomaly kind, which is B anomaly region, it presents the color of green in the figure; the third kind is positive value anomaly kind, which concludes six anomaly regions from C to H, from the figure, it is observed that there are several local anomaly circle in the large orange area.

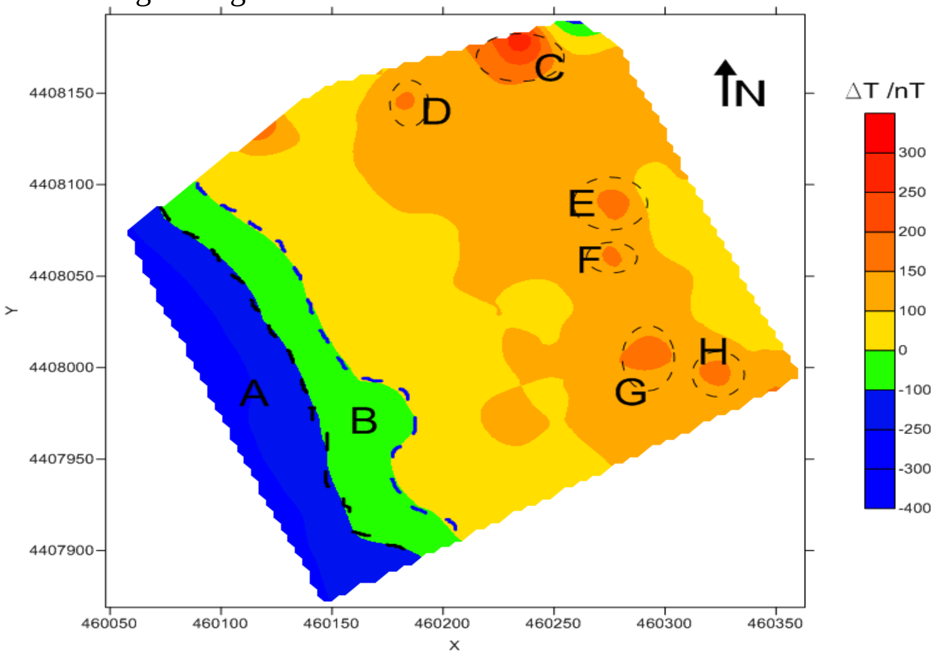


Figure 4. The area distribution diagram of magnetic anomaly

4.1 The negative anomaly kind

From the figure 4, we can see the region A surrounded by black imaginary line from the western edge presents negative anomaly (it presents blue in the figure), it is also can be seen from the magnetic anomaly graph form each profile, most profile present the form that start low, and then raised; combined with the field situation, there is a large area of barbed wire distributed in the measuring border and pipelines under it, so we deduce the negative magnetic anomaly in the west of measuring area is related to it.

4.2 The low value anomaly kind

From the figure 4, we can see the region B surrounded by black and blue imaginary lines presents low value anomaly (it presents green in the figure), in the process of measurement, we can clearly feel the smooth and steady measured value of this region. Combined with the field situation, there are crops and wild vegetation on the field.

4.3 The positive value anomaly kind

Form the figure 4, we can see most regions of the middle part present orange-yellow, and local regions exist high value abnormal point, which are the region C to H delineated by black imaginary line. From the corresponding single profile magnetic anomaly graph, we can see the obvious magnetic anomaly change in the corresponding place. Combined with the field situation, there are many obvious abnormal symbol on the surface of region C, D, G and H (bilge well, barbed wire, metal plate and so on). We haven't see the abnormal material on the surface of region E and F, so we deduce the materials which cause the anomaly distribute in the underground. Following is the detailed analysis of the two abnormal regions.

Abnormal region E: this abnormal region is located near the measure line 225, and 290 (i.e. line 200 meters). Figure 5 is the magnetic anomaly graph of line 225, from it we can see in the vicinity of line 280 to line 290, the high and low abnormal has associated appeared and presented an opposite change obviously. The highest positive value can be reach nearly 200nT, and the lowest negative value can be reach nearly 0nT. Combined with the field situation, we deduce the anomaly is caused by the underground ferromagnetism pollutant.

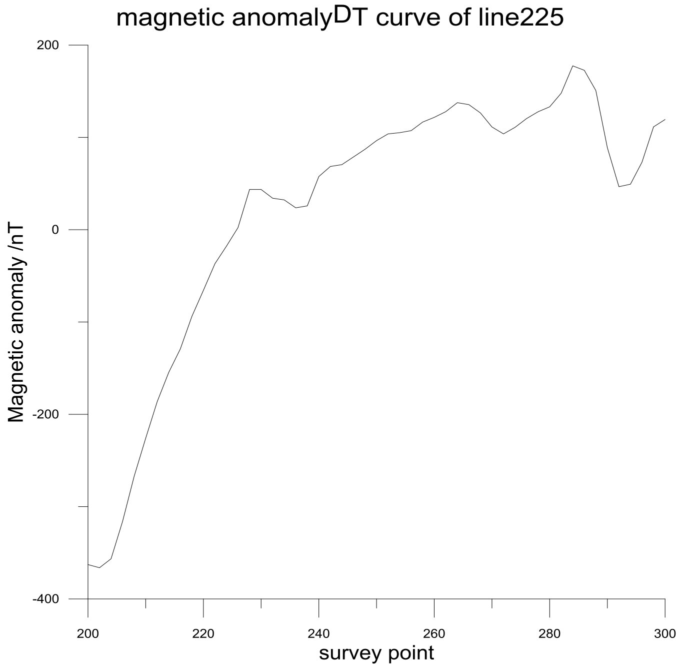


Figure 5. The magnetic anomaly graph of line 225

Abnormal region F: this abnormal region is located near the measure line 200, and 280 (i.e. line 200 meters). Figure 6 is the magnetic anomaly graph of line 200. From it we can see some similarities between here and region E, but the phenomena of high and low anomalies happened together hasn't appeared in here. There is just a high value anomaly has presented near line 280, nearly 200nT. Combined with the field situation, we deduce the anomaly is caused by the underground ferromagnetism pollutant.

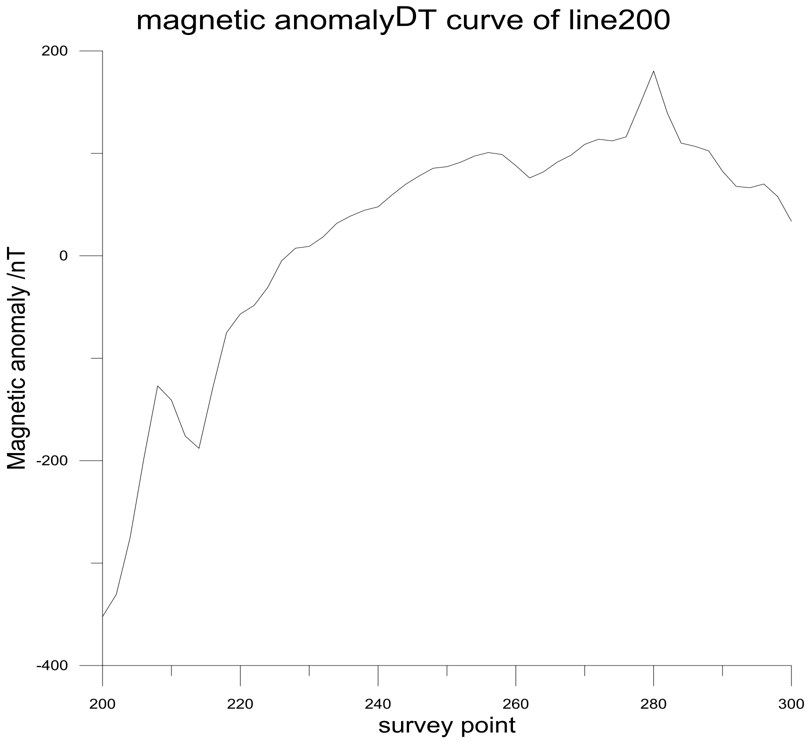


Figure 6. The magnetic anomaly graph of line 200

5. Conclusion

Through the high precision magnetic measurement work for the eleven measuring line in the measuring area, after the data processing, we have obtained that the reginal magnetic anomaly distribution is coincide with the field environment basically. This paper gets the following conclusion after comprehensive analysis:

The effect of high precision magnetic measurement on underground pollutants, especially metal objects detection is significant. The detection process is simple and convenient. It can be applied in the relevant environment protection and achieve satisfying effect.

Combined with some prior information and other measuring information, on the basic of understanding of the type and form of unknown underground metal pollutant, we can further speculate its buried depth to provide the basis for next work.

In order to suppress the multiplicity of single magnetic material and improve its interpretation accuracy, we can detect the key area once again cooperate with other geophysical methods or verify the suspicious area directly.

References

[1] Guan zhining, Geomagnetic Field and Magnetic Prospecting [M]. Beijing: Geological Publishing House, 2005.8

[2] Jia gao, Ye tengfei, Gong Yuling. The Applied Research of High Precision Magnetic Survey in Chromium Slag Pollution Site Survey [C]. The 27th Annual Meeting Collected Papers of Chinese Geophysical Society. 2011:793

[3] Yan tinjie, Xue jian, Zeng zhaofa. The Application of High Precision Magnetic Survey in City Engineering Investigation [J]. World Geology, 2002, 21(4): 368-371

[4] Xu yang. The Exploration of the Application of Magnetic Prospecting in Superficial Layer and Fault Detection [J]. The Earth, 2016, (6):210-210

[5] Lin jinxin. Feasibility Study of the Application of Integrated Geophysical Archaeological Method [D]. Zhejiang Univeristy, 2011

[6] Chu fulu, Liu aipin, Li weidong. The Experimental Results of High Precision Magnetic Survey in Dud Detection [C]. National Security Engineering Geophysical Research, 2006: 157-161

[7] Liu zhaopin, Yang jing, Luo shuiyu. The Experimental Study of the Effectiveness of Geophysical Method to Refuse Landfill Detection [J]. Earth Science Frontiers, 2010, 17 (3): 250-258

[8] Yang jin. Environment and Engineering Geophysics [M]. Beijing: Geological Publishing House, 2011.08