Application of Ground Penetrating Radar in the Detection of Shallow Non-Metallic Targets

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Abstract

In recent years, ground penetrating radar technology is mature day after day. Ground penetrating radar (GPR) has applied in various fields, especially on non-metallic object detection. Taking a surveying project as example, introduces the application of GPR in the related field, and has carried on the preliminary improvement to the method of detection. Explores the dipole spacing in the shallow exploration for the influence of the reception, and parameter Settings, The Angle of the detecting ， filtering algorithm of ground penetrating radar (GPR) in wet porous soil effect on target detection.

Keywords

Ground Penetrating Radar; Dipole Spacing; The Angle Of Detecting Line; Reflexw Software

1. Introduction

Detection of underground target has been a difficult problem for many years, especially detection of non-metallic small object[1]. Due to its absence of magnetic properties, it is difficult to detect in any other way without trace facilities[2]. And ground penetrating radar (GPR) provides the possibility to detect the target[3][4]. After the seventies of last century, with the development and application of modern electronic technology and data processing technology, explore applications of radar technology has been from the weak lossy dielectric such as ice and salt extended to lossy dielectric such as soil, coal and rock etc[5]. Ground penetrating radar has been widely used in geotechnical engineering investigation, hydro geological survey, engineering quality detection, buried objects detection, collapse and karst investigation, mineral resources exploration and archaeological study[6][7][8][9], and its application area is rapidly expanding.

This paper research the application of GPR in detecting shallow targets in the field. As the detection circumstance in yield encountered more moist soil, a large number of electromagnetic wave attenuation in this condition, resulting in the loss of signal and produce a lot of noise, thus increasing the difficulty of signal processing to restore the true information the earth itself is a low pass filter has a shielding effect on the electromagnetic wave. Using low frequency ground penetrating radar, improve detection methods and parameter settings, so as to obtain the effective signal ideal. Experiments rely on a project site in Leshan City, Sichuan Province, using GPR to detect the shallow subsurface target which is already embedded, and based on the principle of GPR and the detection method to try initial experiment.

2. Basic Principles of Ground Penetrating Radar

2.1 The Working Principle of Ground Penetrating Radar.

Ground penetrating radar is a kind of technology that uses radio waves of frequency 25~2300MHz to detect underground structures and buried objects as well as man-made structures[10]. Its working principle is broadly described as follows: Ground Penetrating Radar (GPR) use high frequency electromagnetic wave to broadband pulse wave form through the transmitting antenna to the underground transfer. if electromagnetic wave encounter a dielectric constant mutation formation, it will be reflected to the surface. And reflected signal received by the antenna to receive transmitted to the control system and the data is stored. When the electromagnetic wave propagation in the medium, the path and intensity of electromagnetic field and wave with through the medium of electromagnetic characteristics and geometry and change, so the received signal analysis and processing, judgment of underground structures or buried targets[11]. The detection principle of ground penetrating radar system as shown in figure 2.1.

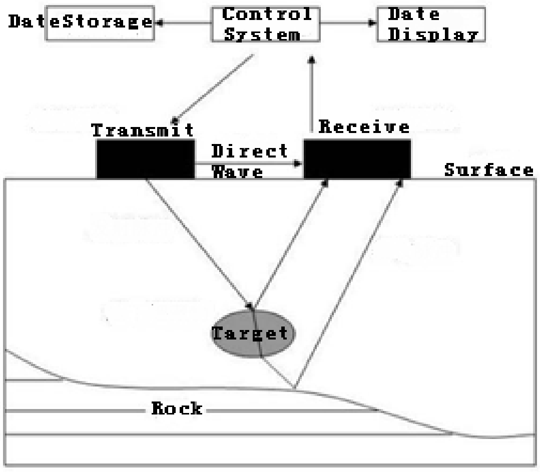

Fig. 2.1 Ground Penetrating Radar Detection System

2.2 Data Processing.

Data processing using the common waveform analysis software Reflexw, applicable to a variety of ground penetrating radar and seismic data processing. For the mined out area of two-dimensional data, according to the field test contrast, the use of the following filtering algorithm:

1) Subtract DC-shift: With this option activated a so-called zero mean, i.e. the subtraction of an existing time constant shift is calculated for each trace;

2) Static Correction: With this option activated a static, this means a time-independent correction for each trace in time direction will be done;

3) Auto Gain Compensate: This function compensate for possible damping or geometric spreading losses;

4) Background Removal: This filter performs a subtracting of an averaged trace, a so called background removal;

5) Bandpass Butterworth: Noise can be suppressed with the bandpass filter when it differs from the signal in its frequency content;

6) F-K filter, This function be used to remove the ground above the peacock reflection signal to reduce its interference with the effective signal;

7) Deconvolution: Deconvolution is so called the inverse filtering or cancel the convolution. Through the basic wavelet compression to improve the vertical resolution of the radar data processing. Ideally, wavelet deconvolution could compress and attenuation multiple wave length;

8) Running Average: This filter method suppresses trace dependent noise. Its effect is to emphasize horizontally coherent energy;

9) Terrain Correction; This function use GPS records to terrain correction, so that the image is more close to the real landscape.

2.3 Image Recognition.

According to the principle of the above ground penetrating radar detection, the characteristics of non-metal objects in ground penetrating radar image is arched wave diffraction. But due to the non-metallic targets and surrounding media, such as the difference between the smaller, generally reflex arc less obvious, which is non-metal detection difficult.

3. Research Contents and Results

3.1 Project Overview.

This experiment is exploration projects in the territory of somewhere, Leshan City, Sichuan Province. To research how to make better use of Exploration Radar in wet porous soils in shallow target detection, artificially in the site for the selected a fixed pre-buried target detection experiments. This experiments use Mala company in Sweden RAMAC series of radar and match the 50MHz RTA non shielded superior coupling antenna. Target depth of 2m or so, target for columnar non metal body, cross-sectional diameter of 80cm.

This experiment uses two kinds of project measurement:

1) Using the default 4.2m dipole spacing, step 420ns, time window 0.4m, sampling frequency 620MHZ, 128 times, the acquisition method for point measurement, manual trigger. Measured line direction and target body long axis into 90 degrees, 45 degrees, 0 degrees;

2) Using 3M dipole spacing (artificial change), step size 0.4m, time window 420ns, sampling frequency 620MHZ, 128 times, the acquisition method for point measurement, manual trigger. Measured line direction and target body long axis into 90 degrees, 45 degrees, 0 degrees.

3.2 Project Results.

The comparison between Fig. 3.1 and Fig. 3.2 shows that the reflection of the target object indicated on Fig. 3.2 is more obvious and much concentrated. In this detection, the equipment's default dipole interval is artificially changed and a better effect is obtained. Analyzed from principle, the electromagnetic wave transmitted from any type radar has a maximum polarization direction, i.e. if the electromagnetic wave-covered angle is within a range, the superiority generated by increase of the dipole interval is the good deep-portion signal and rejection of the shallow-portion signal; otherwise, more shallow-portion signals will be obtained. Adjustment of acquisitioning parameter (dipole interval) and hardware shortens the dipole interval and gets better shallow-portion signal. The experiment shows that trial of adjusting the dipole interval is a method to obtain the shallow-portion signal with the low-frequency antenna. The low-frequency antenna is initially designed for acquisitioning the deep-portion signal and thus the default dipole interval somewhat restricts acquisition of the shallow-portion signal. Artificial change of the dipole interval will make the shallow-portion much covered by the electromagnetic signal, and by this way, more shallow-portion signals will be received by the antennal receiving terminal.

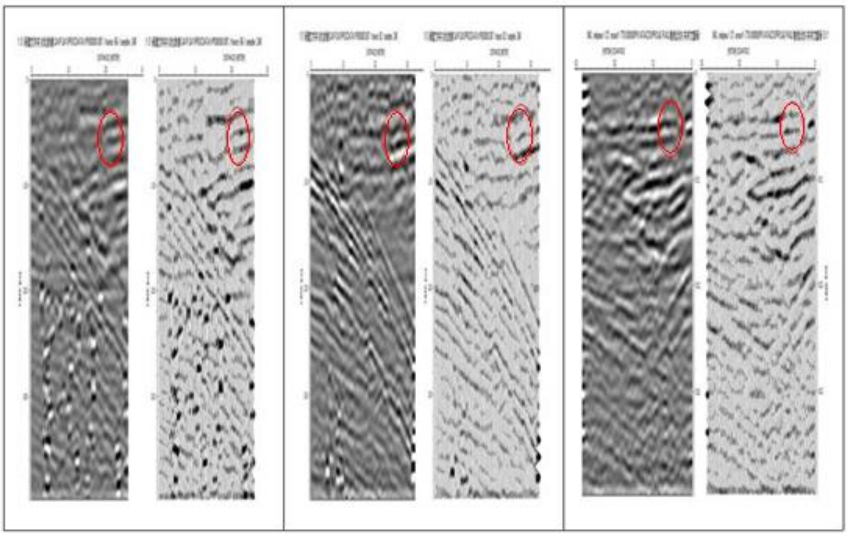

Fig. 3.1 Plan One 90 Degree (left), Plan One 45 Degree (middle), Plan One 0 Degree (right)

From Fig. 3.2, it is clear that the pictures of target object scanned with different angles will be different, of which, the target object scanned with angle 90 °(Fig. 3.2 left) is reflected obviously and whose energy is concentrated. Hence, it is judged that too small inclusion angle between the major axis and the survey line of the target object would result in increase of cross sectional area and unobvious uneasy discriminatory reflection. Thus, before acquisitioning data, it is necessary to find out the approximate shape and basic space position of the object to ensure the correctness of the data. In case of no reference condition, comprehensive judgment shall be made in combination with horizontal lines, lateral lines and even oblique lines.

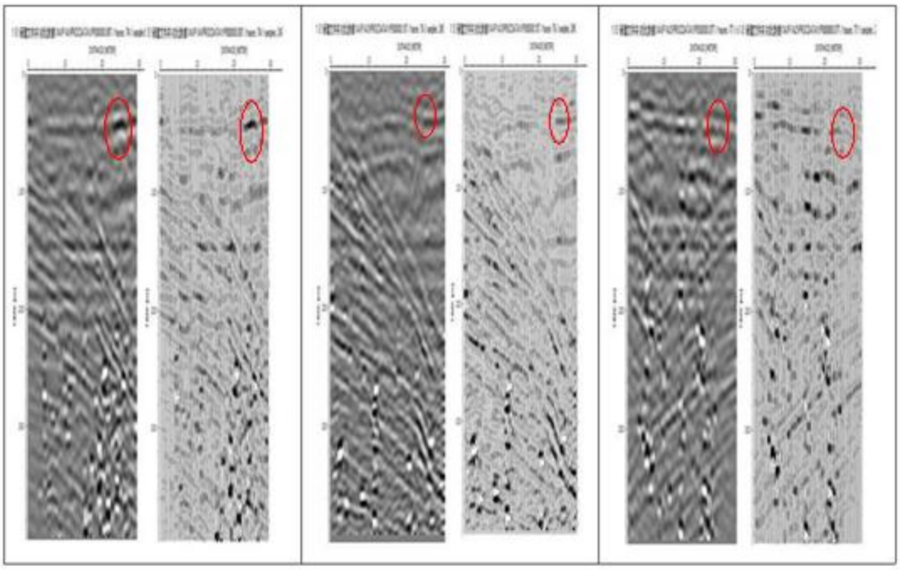

Fig. 3.2 Plan Two 90 Degree (left), Plan Two 45 Degree (middle), Plan Two 0 Degree (right)

3.3 Application of F-K Filter in Ground Disturbance.

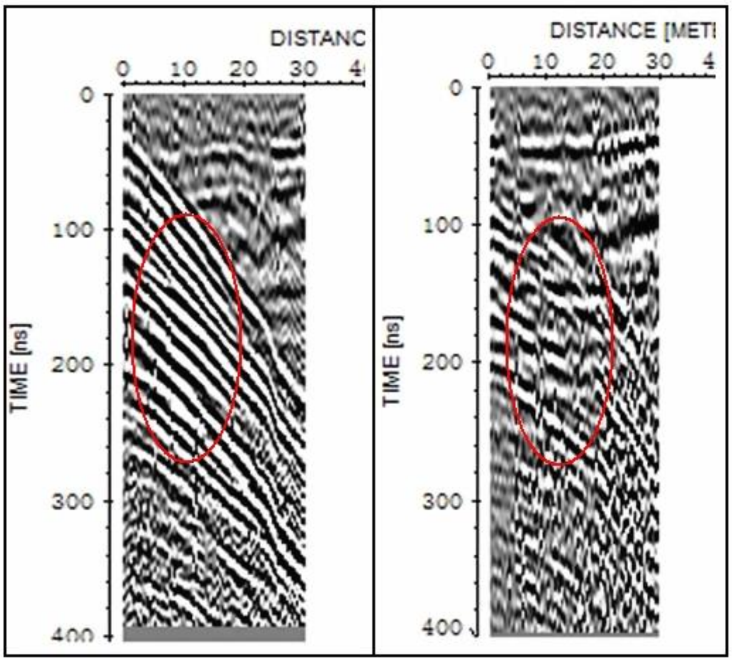

Fig. 3.3 Comparison of F-K filter

From the pictures, it is clear that there are several groups of oblique homogenous axis, which is attributed to the fact that one side of the detection field is a cliff. This is the weakness of the non-shielding antenna, and it is very sensitive to surface interference signal. It is clear from the change rules in the time-depth and movement distance along the survey line direction that this experiment is arranged in a direction from the cliff outwards. The signal which is transmitted from the space and propagated from a period and the signal simultaneously reflected from the surface are supposed and received by the antennal receiving terminal, which generates the oblique false signal. As long as the field record is well made to master the rules of the signal, this signal will be thoroughly eliminated. Processing is made with F-K filter in the reflex software. In this experiment data, use of oblique pattern compressed with band-filter in F-K obtains good effects (Fig. 3.3). The so-called F-K filter is the filter in the frequency wave number range [12], by which the clutter is inhibited on basis of difference between its apparent velocity from that of the useful signal of the echo signal.

4. Conclusion

Ground penetrating radar as an economic, rapid, non-destructive geophysical methods, will be used in more and more fields. With the electronic technology and filtering technology developed, ground penetrating radar detection accuracy and depth will increase greatly on this basis. The ground penetrating radar is a new type of underground detection means, which has a great prospect. At the same time, through this experiment, it recognize that we should choose the appropriate model of the antenna parameters and detecting process to obtain satisfactory result for the different detecting purposes an different detecting conditions. In addition, the filtering treatment should be appropriate to avoid interference and keep the effective the signal as far as possible. Only in mastering the principle of ground penetrating radar and improving detecting method reasonably can we obtaining a reasonable result. The preliminary experiment confirmed the feasibility of this method in the practical application and it will enlighten the future exploration. Under constant exploration of electromagnetic wave detecting technology, ground penetrating radar (GPR) will be widely applied in various engineering fields.

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