جامعة الانبار

كلية العلوم -قسم الجيولوجيا التطبيقية

اسم المادة بالعربي: الجيوفيزياء الجهدية - الطرق الكهربائية

اسم المادة بالإنكليزي: Potential Geophysics- Electrical Methods

عنوان المحاضرة: GPR Method- GPR Hardware

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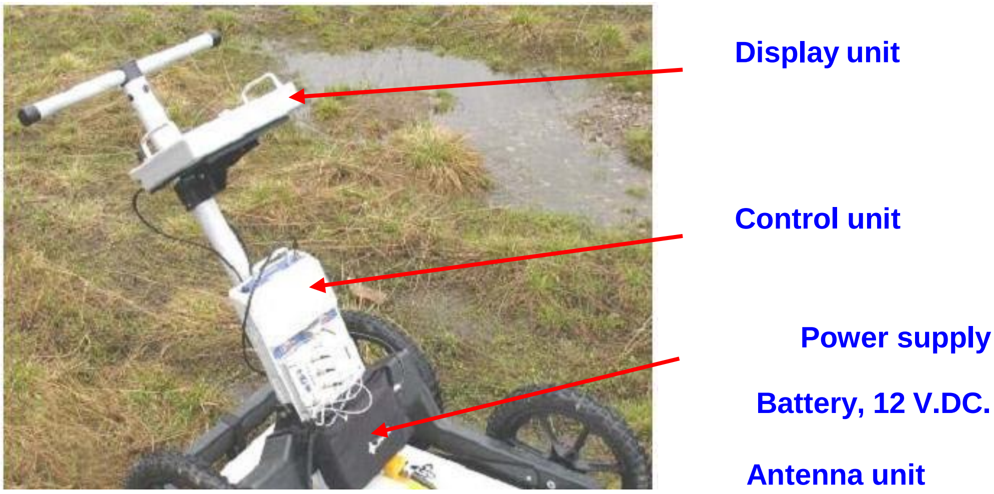
GPR Hardware

GPR instrument

The GPR instrument is composed of a transmitter, a receiver, antennas connected to them, a controlling unit and a signal display with a recording system. All these components are equipped in one unit in some systems and have D.C power battery; Typical GPR equipments are shows in (figure 2-12).

The manufacturers offer different configurations of these components. The majority of commercial GPR systems allow operation with a number of interchangeable antenna units with different centre frequencies to suit the soil conditions, depth of penetration and resolution required.



Display unit

This unit in GPR is to display the profiles (radargrams) during the measurements, and it could be standard monitor supplied from the company (figure 2-13), or could be external laptop. In both monitors there is a software that identify the parameters setting of the GPR units through windows system or any type of operating systems. This software called a ground vision software (MALA Geoscience, Operating Manual of RAMAC MALA).

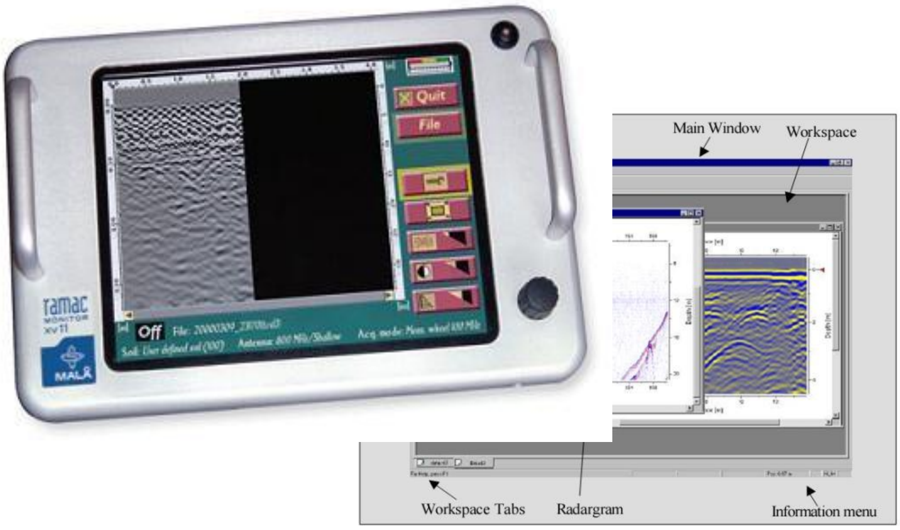


Figure (2-13) shows the display unit (Stander monitor) for GPR MALA Geoscience, Operating Manual of RAMAC MALA)

Control Unit:

The radar control unit is the main part of a GPR system (figure 2-14). It administrates the radar data collection. The control unit contains the electronics that produce and regulate the pulse of radar energy that the antenna sends into the ground and record the reflect signals then display it on the screen unit of the GPR. It consists of a power supply .MALA control units are compatible with all current MALA antennas, both unshielded, shielded, borehole and high frequency antennas. (MALA Geoscience, Operating Manual of RAMAC MA

Antenna Unit:

This unit is responsible about sending and receiving the EM signals. There are two types of the antenna; shielded type (monostatic), and unshielded type (biostatic).The shielded type contains the transmitter part (TX) and the receiver part (RX), and it are separating in unshielded type. There are special specifications for each type of the antennas (weight, dimensions) depending on the range of frequency used (figure 2-15). This unit has different specifications of frequency depend on the aim of surveying, (tables 2-3, 2-4). (MALA Geoscience, Operating Manual of RAMAC MALA)

Dimensions: 74 x 44 x 16 cm Weight: 7.85 kg

Dimensions: 50 x 30 x 16 cm Weight: 5.0 kg

Dimensions 38 x 20 x 12 cm Weight: 2.6 kg

Figures (2-15) shows several of shield antenna type MALA Geoscience, Operating Manual of RAMAC MALA)

2.10.1.4 Power supply

. Each unit of GPR system requires a power supply to function adequately throughout the working day (figure2-16). This power is usually supplied from a 12V Li-Ion battery but a direct supply may be possible from a vehicle-mounted system. The battery packs are of Li-Ion type, with a battery capacity of 7.5 V / 8.8 Ah. This gives an operating time of 4 to 6 hours. The battery should always be stored fully charged to maximize the lifetime of the battery.

Figures (2-16) shows the battery of control unit, MALA Geoscience, Operating Manual of RAMAC MALA)

2.11 GPR software:

The software of GPR method can be divided into three types:

Operating & Data Acquisition Software: -1

This software operates the device, modifies the operating settings, and work on data collection such as Ground vision software. In addition, it is possible to apply some filters (basic processing) during this software.

Processing software: -2

This software run after the raw data (radargrams) collection. There are multiple processors can be run by this software such as the apples of the filtering .The uses of this software is necessary, and it is very hardly to interprets the raw data with out used it, so it imposed use. It is recognizes with high-resolution filters and special tools to processing the raw data (radargrams). In addition, it is possible to interpretation the raw data (radargrams) in this stage of processing.

Mapping & (3D) Models software: -3

These software can be used after the completion of the processors. The best results of processors lead to give good data can be used to the maps and (3D) models of underground features. Surfer program is one of the important software to represent the maps, and 3d models.

2.12 The modes of GPR:

GPR technique can be used three basic modes, which depended on way of signals reflection and antenna arrangement (figures 2-17, 2-18). **(A) Reflection Profiling Mode (Common offset Mode):**

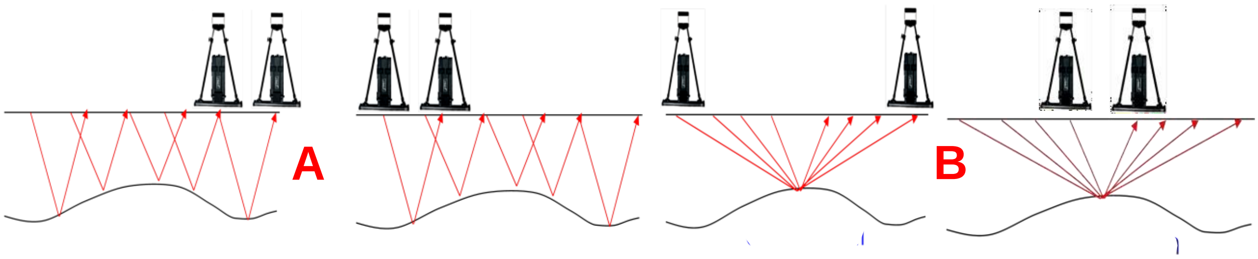
. In this mode, the distance between the transmitter (Tx) and receiver (Rx) of antenna is fixed, and both antennas (Tx)(Rx) are moved together over the earth surface (figure 2-17 A). This is the most commonly used made, and it is possible to use the shielded and un shielded antenna (Annan, 2001).

The properties of this mode can be mentioned in the points below:

* Reflection points are images by one raypath only.
* Easily interpretable data.
* Signal-to-noise ratio can be poor.
* Image resolution can be low.
* Processing power is limited.

(B) Wide-angle Reflection Mode (WAR) or (CMP):

. In this mode, the distance between the transmitter (Tx) and receiver (Rx) of the antenna is changed, the transmitter and receiver are moved away from each other so that, the midpoint between them stays at the same location (figure 2-17 B). In Common Midpoint (CMP) acquisition, the same point is images many times, resolution of each point is enhanced, isolated data is not particularly useful, many processing steps can be applied, (Yilmaz, 1998).



Figure(2-17)shows the Operation Modes, (A), Reflection Profiling, (B), WARR Mode

(Adams RB and Won IJ, 2000)

(C) Borehole mode:

In this mode, one or both GPR antenna (transmitter and receiver) are positioned in a borehole. Rarely, applied to archaeological settings, probably due to the risk of damaging artifacts on drilling the borehole. Therefore, this mode in this case of survey construed as destructive testing in investigation of man-made structures. Particularly useful for: exceptional imaging, rescue archaeology, imaging beneath conductive layers (Annan, 2001).

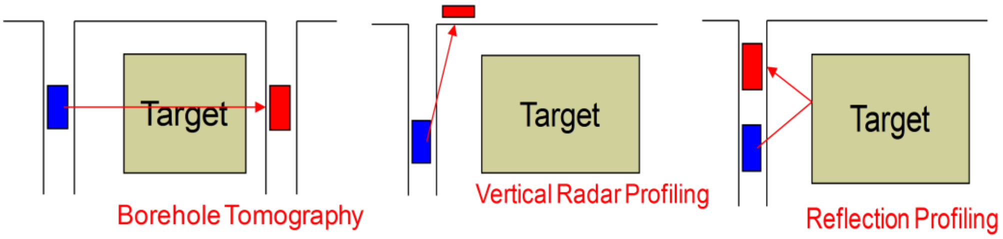


Figure (2-18) shows the Operation Modes: Borehole mode. (Adams RB and Won IJ, 2000)

2.13 Evaluation of the GPR technique performance

As in all geophysical methods, the most important step in Ground Penetrating Radar (GPR) survey is to define the problem or the aim of the investigation. The objective of the study determines the specific mode of operation for the radar study (Davis and Annan ,1989). There are five basic information should know before starting radar survey if going to be effective:

1. The approximate target depth. This information will help the investigators to choose the frequency range and type of antenna (shielded, unshielded), which should cover the depth of the target.

2. Target geometry. The most important target factor is target size (height, length, width). If the target is non- spherical, the target orientation (strike, dip, plunge) must be qualified.

3. Electrical properties of the target and the host material of the target, the relative permittivity (dielectric constant) and electrical conductivity must be quantified, If the host material exhibits variations in properties which are similar to the contrast and scale of the target, the target may not be recognizable in the myriad of responses (commonly referred to as volume scattering and clutter) generated by the host environment. The target must

present a contrast in electrical properties to the host environment in order that the electromagnetic signal modified, reflected, or scattered.

5. The survey environment type. This information is collected during the exploratory field visits which including possibility of finding some of metal structures, magnetic sources, etc., because GPR is sensitive for surround materials.

The data above is almost important, and will help the investigators to build survey design plan, and chose the best specifications of GPR instrument to carry out the survey.

All the values entered in that table are empiric and approximate. therefore not necessarily correspond to theoretically calculated .

Antenna Frequency (MHz)	Suitable Target Size(m)	Approximate Depth Range (m)	Approximate *MAX.* Penetration Depth(m)	Recommended sample frequency (MHz)	Recommended Trace interval (m)
25	1.0	5-30	35-60	150-600	0.30-0.75
50	0.5	5-20	20-30	400-800	0.20-0.50
100	0.1 - 1.0	2-15	15-25	800-1800	0.10-0.30
200-250	0.05 - 5.0	1-10	5-15	1600-3500	0.03-0.10
500	0.04	1-5	3-10	4000-7000	0.02-0.05
800	0.02	0.4-2	1-6	6500-14000	0.02-0.04

Table (2-5) shows the recommendation settings for data collection relative to center frequency (Operating manual of RAMAC)

GPR survey Method:

GPR method is a geophysical method; the geophysical methods have three stages of survey system depending on the aim of survey, the stages are:

Data acquisition:

This stage of the fieldwork . including the profiles surveys . The accuracy of initial collected information such as, topographic, geological description, hydrological description, tectonic description, wave noises sources, locating the site and planning the profiles…etc., lead to the collected accuracy data. The best results of GPR survey depended on appropriate the information from the exploratory field visits with the accuracy of using the operating parameters setting of the GPR relative to the target of the survey.

2.14.2 Data Processing:

. Data Processing is not separated from the process of data acquisition, but it is connected with each other .The accuracy of the data acquisition will lead to success of the process procedures . The collected raw data passes with special steps of the processing such as reflection method, and that by using special type of software such as (RAD Explore software in RAMAC MALA system software). There are many reasons make the applying of processing is necessary such as the heterogeneity of the soils, ,surface noise signals, …etc. . . The processing procedures of raw data can do with high-resolution results if the procedures doing well and removing and fixing all the unwanted signals from the raw data , but the uses the deep processing that means the use of filters in very high or very low range lead to data mutilation and give Image is not realistic for the depths and shapes of objects beneath the surface (Annan, 2001). Sometimes the problem posed can be solved by a GPR survey just be looking at the raw data (such as locating the horizontal position of a pipe).Other times, the data have artifacts associated with logistical constraints, antenna or system characteristics, or other problems that need to be removing. . The steps of the processing is different in each case of raw data but in general the processing includes four fundamental steps depended on the aim of the study and resolution of collected data.

These four fundamental steps are:

Data editing

The first step in processing is data editing. Field acquisition is seldom so routine without errors. Data editing including issues such as data re-organization, data file merging, data header orbackground information updates, repositioning and inclusion of elevation information with the data.

This step of processing is the one where re-organization and sorting of multifold coverage data would be handled. The steps are essentially the same as with multifold seismic data (Fisher et al, 1992, Annan, 2001).

Basic Processing

The basic processing should not be such that it radically distorts the information from that which was collected .The initial basic processing step is usually temporal filtering to remove very low frequency components from the data. This step is frequently referred to as ‘de-wowing’ the data. Very low frequency components of the data are associated with either inductive phenomena or possible instrumentation dynamic range limitations. This process has historically been done using analog filters in hardware but with the advent of true digital acquisition this has also become a data processing issue also applying some types of filtering (Gerlitz et al, 1993).

Table (2-6) shows some of the most important basic filters in RAMAC MALA GPR software.

Table (2-6) shows some of the most basic important filters which apply in Mala software

Filter Name	Description
DC Filters	There is often a constant offset in the amplitude of the registered trace, this is known as the DC level or the DC offset. This filter removes the DC component from the data.

Time Gain	applies a time-varying gain to compensate for amplitude loss due to spreading and attenuation or attempts to adjust the gain of each trace by equalizing the mean amplitudes observed in a sliding time window
Background Removal Filter	removes horizontal features or almost horizontal features from the data by applying a horizontal spatial high pass filter.
Band-pass Filter:	remove unwanted frequencies from the traces. Frequencies below the lower cut-off frequency and above the upper cut-off frequency are attenuated
Running Average	smoothes the radargram by replacing each sample with the mean value calculated from all samples in a window centered on the active sample
Subtract Mean Trace	used to remove horizontal and nearly horizontal features in the radargram by subtracting a calculated mean trace from all traces

In RAMAC MALA GPR there are three types of filters works during field measurements (figure 2-19):

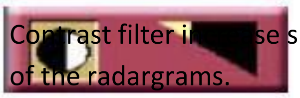
D.C removal filter. -1

Contrast filter. -2

Time Gain filler. -3

The function of these filters is to view and check the quality of collected raw data in the field.

Background removal filter. (BKG)



Contrast filter i[illegible]se sharpness of the contrast among the reflected events of the radargrams.

Applies time gain on the measured traces. The settings of this filter can be changed

Figure (2-19) shows the types of filters in the main screen unit of GPR instrument

Advance Processing:

Generally, the important feature of advanced processing is that it focuses on making weaker signals visible, and enhances specific components of the data for an interpretation requirement or derives quantitative information such as velocity and attenuation versus depth from the data. Also have the potential of introducing artifacts in areas where there are no responses in the ground giving rise to specious interpretations so that care must be used when processing radar data because artifacts can be in advertently introduced into the data including analysis, utilities like power spectrum in frequency domain f-k spectrum, velocity curve-fitting (Velocity Fitting) velocity spectrum and amplitude Analysis. Processing in this class will often result in data that totally changed from the original data set (Tillard & Dubois, 1992).

2.14.3 Interpretations:

The final stage of the investigation is interpretation, also related to the stage with the previous two stages and the success of the interpretation depends on the accuracy of data collection and processing and analysis of raw data. The process of GPR interpretation begins with the specification of the problem and the design of the data acquisition survey.

GPR signal interpretation has many similarities to the seismic signal interpretation, and many techniques developed for seismic signal processing are used in GPR. However, the most important differences of the seismic survey and the GPR survey are the time for data acquisition and interpretation (Yilmaz, 1987). In many applications of GPR, the data acquisition is quick and the signal some cases interpreted on site in real time. On the contrary, seismic survey needs much longer time and interpretation cannot be carried out in real time.

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