# Introduction to Ground Penetrating Radar (GPR)

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About GPR

Ground Penetrating Radar (GPR) is a non-invasive method of material analysis based on transmitting an ultra wide band EM signal into the materials. A part of the EM wave is reflected when it reaches a boundary between two materials with different electrical properties. The reflected signal gets recorded at the source of the EM wave and is displayed for the operator and frequently recorded for later analysis.
The first commercial GPR systems were developed in the early 1970's mainly for mining applications. During the last 40 years they have evolved greatly, starting as analogue instruments and entering the digital era sometime during the 1990's. Today there are many GPR manufacturers in the world and GPR technology is being used for different applications like geology, mining, archeology, utility detection, road surveying, environmental surveying, construction inspection and many more.
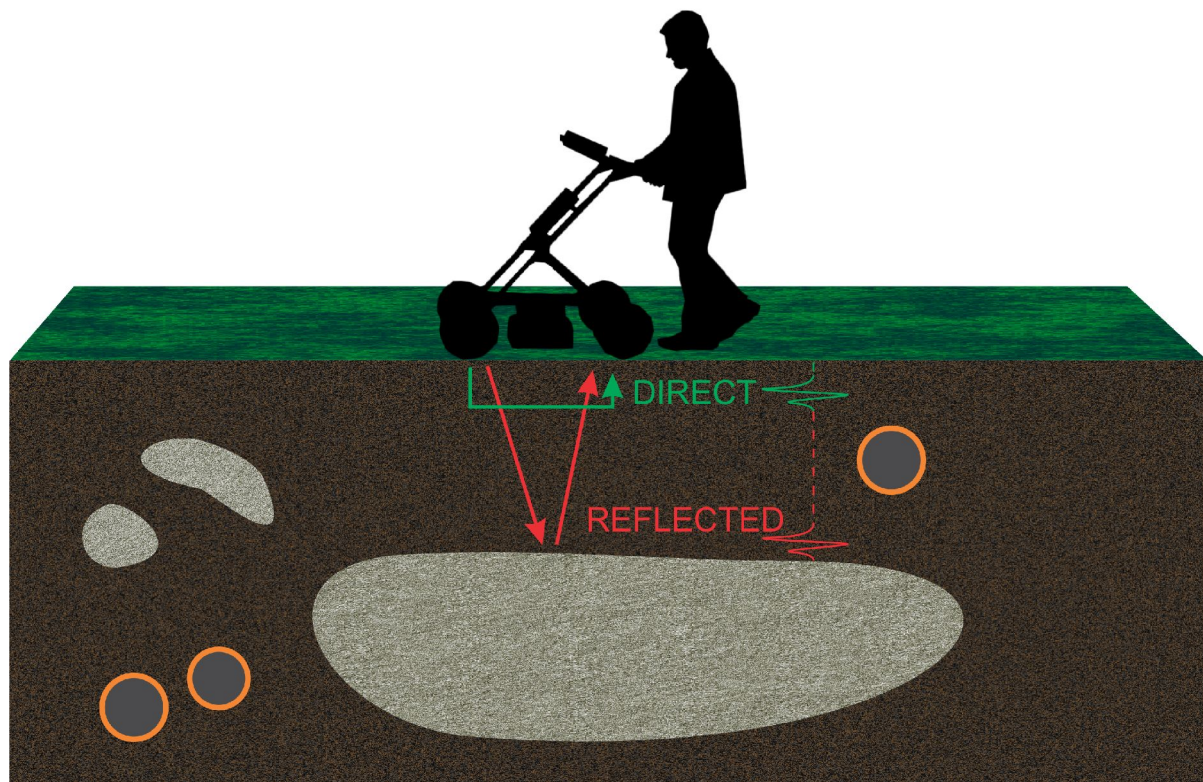
The GPR system consists of a transmitting and receiving device (antenna), signal control device (control unit), user control unit with data recorder (laptop) and the power source (battery). Although most of the today GPR systems are light-weight more often than not they are mounted on a cart or harness. This allows the user to move easily while collecting the GPR data.

Table of settings and applications for the Geoscanners AB antennas

| Antenna name	Recommended settings			Size of target (m)	Recommended area of application
	HP(MHz)	LP(MHz)	Range (ns)		
GCB100	50	200	50-400	0.5	Deep stratigraphy and deep utility survey
GCB200	100	400	30-200	0.25	Medium depths stratigraphy and utility survey
GCB300	150	600	20-120	0.15	Medium depths stratigraphy and utility survey
FLB390	200	800	15-75	0.125	Medium to shallow depth stratigraphy and utility survey
GCB400	200	800	15-75	0.125	Medium to shallow depth stratigraphy and utility survey
GCB500	250	1000	10-50	0.1	Shallow depths layer and utility survey
GCB700	350	1400	7-35	0.07	Shallow depths layer and utility survey
GCB1000	500	2000	5-25	0.05	Shallow depths layer and utility survey, structural inspection
GCB1500	750	3000	3-20	0.015	Structural inspection
GCB2000	1000	4000	2-10	0.0125	Structural inspection
HA1000	750	2000	7-30	0.05	Road inspection, structural inspection
HA2000	1000	4000	5-15	0.0125	Road inspection, structural inspection
BA100	50	200	50-400	0.5	Borehole high range inspection
BA500	250	1000	10-50	0.1	Borehole medium range inspection
BA1000	500	2000	5-25	0.05	Borehole near range inspection

⚠ Values in the table are to be used as a rule of thumb. The values for the range and size of the targets are derived from tests on an average soil survey site, with low conductivity (<1mS) and with a relative dielectric permittivity equal to 9.
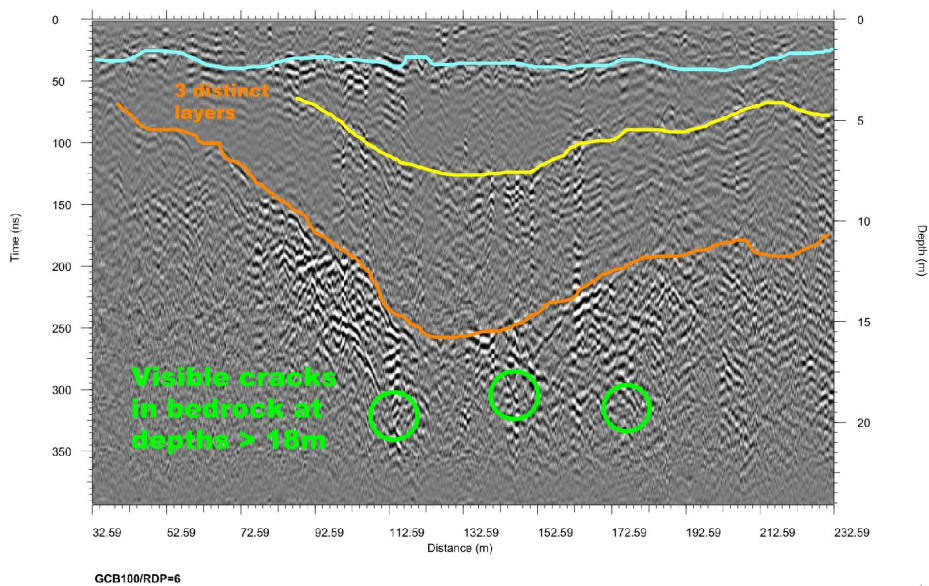
Antenna area of application and examples

Stratigraphy

Stratigraphy is a survey process to determine ground conditions - more precisely layers, disturbance, homogeneity, water table levels etc.
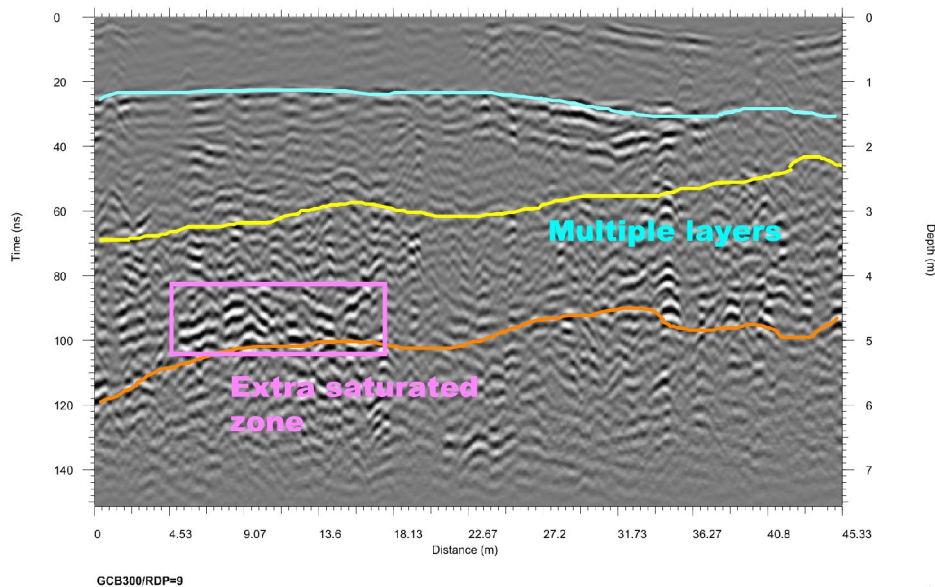
GCB-200, medium depth stratigraphy, dry soil

GCB-100, deep stratigraphy dry soil

Deep

Depths of interest vary from 5-30 meters and shallow objects are disregarded. The amount of traces is lowered as much as possible due to the characteristics of the target (layers usually don't change abruptly in a few cm).
Antenna recommended for the survey: GCB100.

Medium depth

Depths of interest vary from 3-10 meters and the majority of shallow objects are disregarded. The amount of traces amount is lower than for shallow applications, but slightly higher than for deep surveys. This is a result of smaller targets like voids and water leakages.
Antenna recommended for the survey: GCB200, GCB300,GCB400

Shallow

Depths of interest vary from 0-2.5 meters and the amount of traces is the highest for these applications. In this case we will be interested not only in the layers, but probably in possible cracks as well.
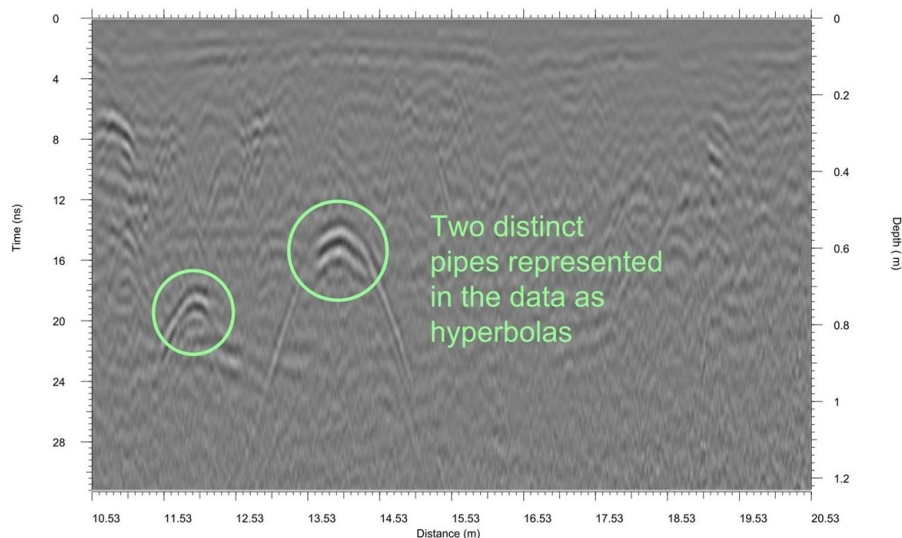Antenna recommended for the survey: GCB400,GCB500,GCB700, GCB1000

Utility detection

Utility detection is a survey process to determine the position and depth of man made objects – more precisely pipes, cables, tunnels, trenches etc.

Old army tunnel
through bedrock
top at 6.5m
bottom at 8.5m
width 4m
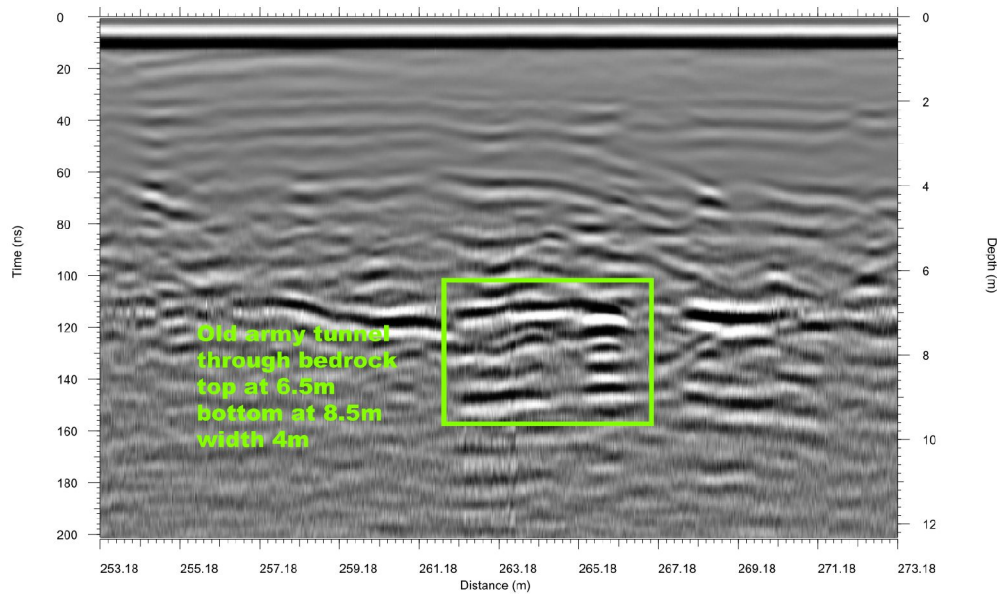
GCB100/RDP=6

GCB-100, deep utility detection, average soil

Two distinct
pipes represented
in the data as
hyperbolas

GCB700, RDP=6

GCB-700, utility detection, average soil

Deep

Depths of interest vary from 5-30 meters and shallow objects are disregarded. Trace amount should be reasonably big so the point objects are not overlooked. For this kind of survey, targeted objects have to be large and good reflectors.
Antenna recommended for the survey: GCB100.

Medium depth

Depths of interest vary from 3-10 meters and majority of shallow objects are disregarded. Trace amount should be reasonably big so the point objects are not overlooked.
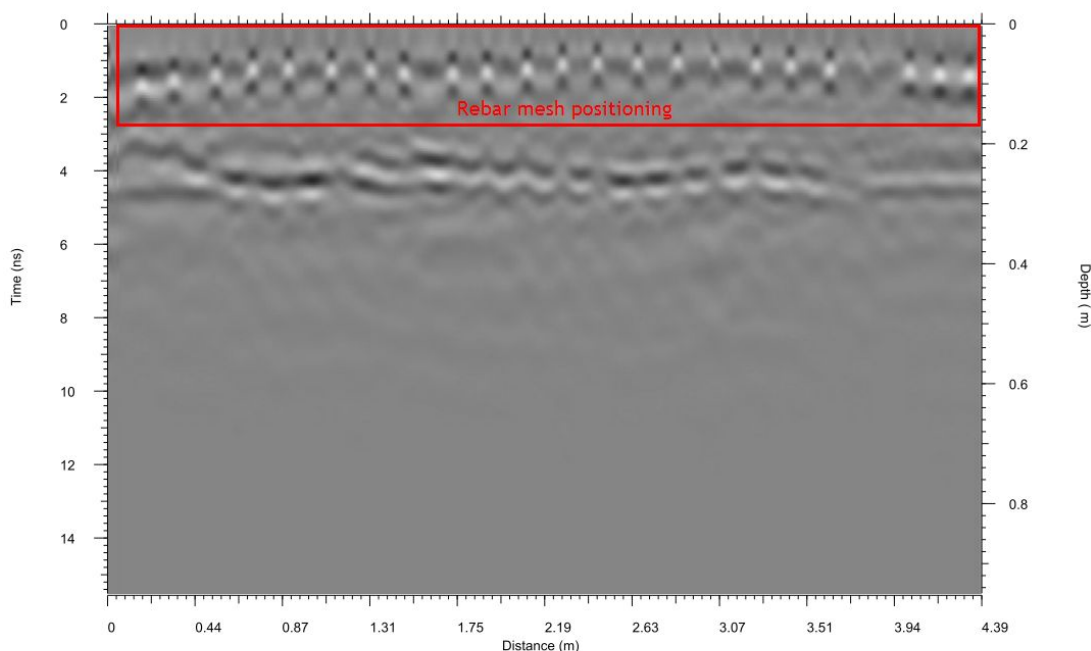Antenna recommended for the survey: GCB200, GCB300, GCB400.

Shallow

Depths of interest vary from 0-2.5 meters and trace amount should be reasonably big so the point objects are not overlooked.
Antenna recommended for the survey: GCB400, GCB500, GCB700, GCB1000,GCB2000

Structural inspection

Structural inspection surveys are high resolution surveys providing us with a tool to evaluate the condition of materials used as building blocks. Examples of these kind of surveys are concrete, ice and timber inspections but the same principles can be used with any material. When it comes to structural inspection the goals of survey usually consist of positioning objects (rebars), disturbance (delaminations and cracks) and determining homogeneity of the material (segregated pockets, water saturation). Depth of interest vary from 0-1.5m. In case of survey sites with problematic surface contact one can use horn antennas as well.

**GCB-1000, concrete deck with rebar mesh, filtered and migrated**

Antenna recommended for the survey: GCB1000, GCB1500, GCB2000, HA1000, HA2000.

Road assessment

This kind of survey uses one or combines multiple antennas in order to get the assessment information about the road. Information on thickness (asphalt, underlayer and base of the road) and quality (de-lamination, saturation and cracks) of road structures provides the data for evaluation. The nature of this surveys dictates in most cases mounting the equipment on a vehicle and moving at speeds that demand non-contact antennas. However, there are cases when a more local survey in restricted areas is necessary, for instance roundabout inspection.
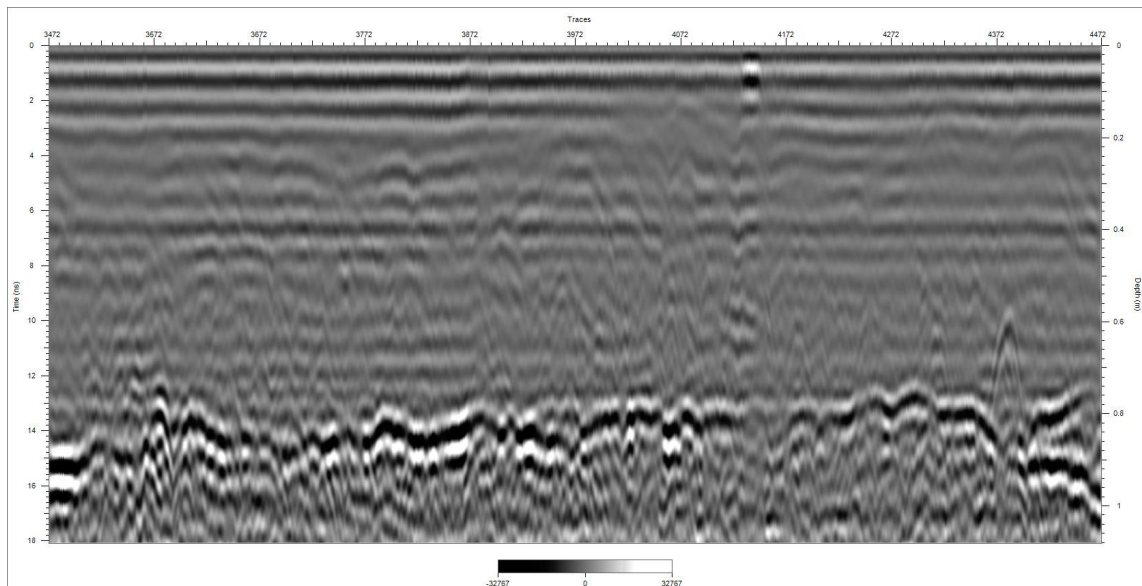

Road survey, horn antenna HA1000, raw data

Antennas recommended for the survey: HA1000, HA2000, FLB390 and GCB-1000.

Borehole surveys

Borehole surveys are based on creating subsurface images of the site by using drilled boreholes in order to move the antenna vertically or horizontally. This approach is also one way to get below upper highly conductive layers and collect the data. Data is recorded as a collection of 360 degrees traces for each and every depth the antenna is lowered to. in other words one creates horizontal depth slices based on the position of the antenna. Borehole antenna s have also been successfully used in a tomography surveys and borehole-to-borehole surveys.
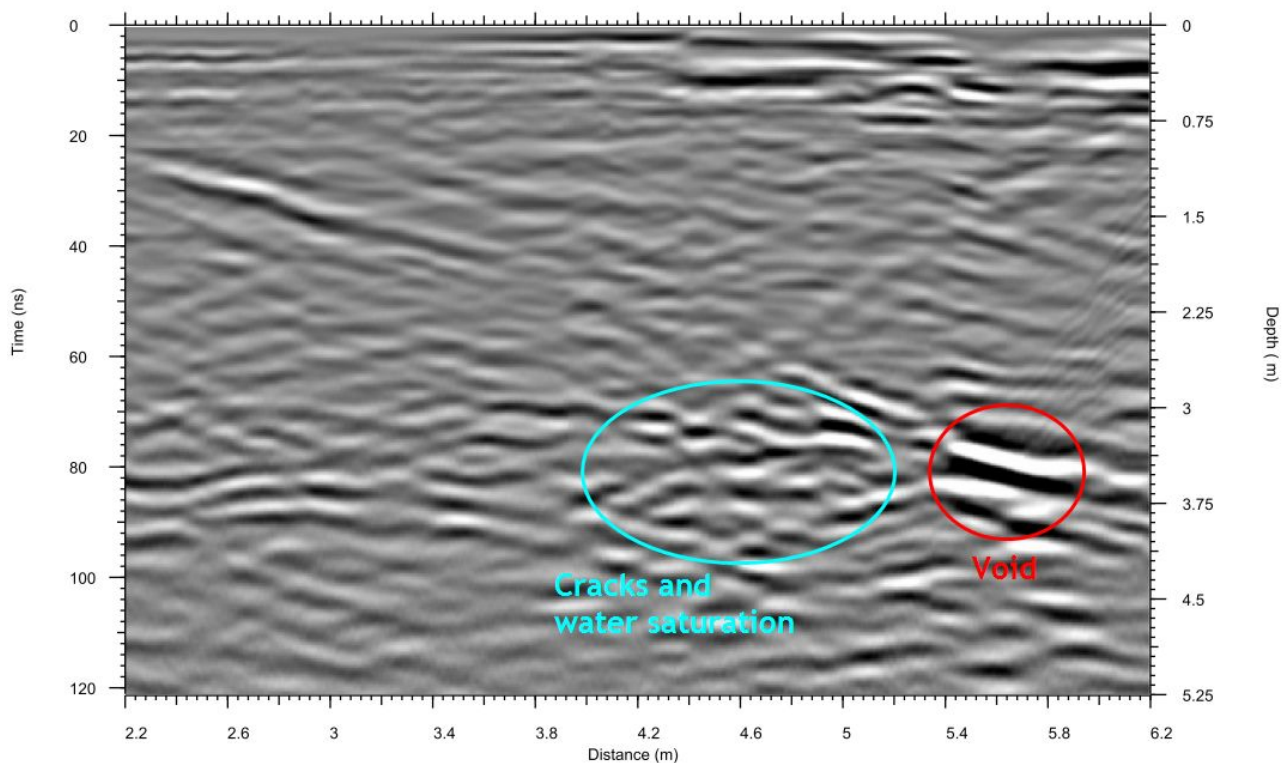
BA500 data , mine tunnel inspection, average soil

Antennas recommended for the survey: BA100, BA500, BA1000.