

Features of RADPRO

RADPRO is a kind of software package that provides various data processing techniques, editing, analyzing and displaying tools for GPR (Ground Penetrating Radar) data. **RADPRO** also can process and display the data acquired by the borehole radar exploration, such as borehole reflection survey, vertical radar profiling, and tomography. The data processing schemes provided by **RADPRO** are categorized into two groups. The first one, normal data processing, incorporates 17 signal processing programs. The second one, special data processing, consists of the interactive filtering in frequency-wavenumber domain and the finite difference migration. **RADPRO** also provides several ways to analyze frequency spectrum, $f-k$ spectrum, velocity, and amplitude. To help the user to edit GPR data more conveniently, **RADPRO** provides a unique way to edit GPR data on screen, graphical editing. Also available are several utilities such as picking travel time of a certain event. Various radar images can be created and they also can be exported as graphic image files for use in other applications.

1. Data Processing

Data processing of **RADPRO** is divided into two categories, normal data processing and special data processing.

1) Normal data processing

Following processing programs are available. Each processing tool in normal data processing can be applied with arbitrary combination. In order to select the optimal processing parameters and sequence, **RADPRO** provides *Test Processing Window* in which we can compare the processed results with different parameters. Once the optimum processing sequence and parameters are established, multiple files can be processed at once by *Batch Processing*.

DC Filter: removal of DC component.

Dewowing: removal of 'wow'.

AGC (Automatic Gain Control)

Gain: applying exponential gain function.

Custom Gain: applying user-defined gain function.

Trace Equalization: making the energy level of each trace equal.

Filter in Frequency Domain: band-pass, low-cut, and high-cut filtering in frequency domain.

Filter in Wavenumber Domain: band-pass filtering in wavenumber domain.

Predictive Deconvolution

Median Filtering in Time: smoothing traces by taking median value along the vertical axis, i.e., in time domain.

Median Filtering in Distance: smoothing traces by taking median value along the horizontal direction, i.e., in distance domain

Smoothing by 2-D Median Filter: smoothing traces by taking median value of neighboring 9 samples (3x3) in a 2-dimensional way.

Delete Mean Trace: subtracting mean trace from each trace.

Remove Horizontal Events: subtracting mean or median trace from each trace.

Horizontal Moving Average Filtering: smoothing traces by taking the weighted average of the neighbors of each trace.

NMO correction: Normal Move Out correction

Migration by Constant Velocity: f - k migration

2) Special data processing

RADPRO provides two kinds of special data processing tools. The one is interactive filtering in the frequency-wavenumber (f - k) domain. The f - k domain filtering in **RADPRO** means that we manipulate our data in the f - k spectrum, for example, muting any arbitrary unwanted region in the spectrum. The interactive GUI (Graphical User Interface) environment of **RADPRO** makes the filtering tasks much easier. The f - k domain filtering is divided into ***velocity filtering*** (Pie slicing) and ***f - k filtering*** (arbitrary shape slicing).

The other special data processing scheme is ***Finite Difference Migration***. If the velocity of radar wave in underground is nearly constant, ***Migration by Constant Velocity*** of normal data processing is enough. However, when the underground velocity changes significantly in horizontal and/or in vertical directions, it can produce highly distorted image. For that situation, **RADPRO** provides another migration tool, ***Finite Difference Migration***. The special feature of finite difference migration of **RADPRO** is to provide a way to image underground correctly without any correction, when GPR data are acquired in areas with irregular topography.

2. Data Analysis, Editing, Utilities

RADPRO provides various ways for editing and analyzing GPR data, and utilities to help us to process and interpret GPR data.

1) **Data analysis:**

All analysis tools of **RADPRO** are categorized as frequency spectrum analysis, frequency-wavenumber spectrum analysis, and velocity analysis. And also possible is to analyze amplitude.

Power spectrum in frequency domain

f-k spectrum

Velocity curve-fitting (Velocity Fitting)

Velocity spectrum

Amplitude Analysis

2) **Data editing:**

One of special features of **RADPRO** is the capability of editing GPR data visually. We can select traces, move or copy and paste them to the any position we want, just with the mouse in **RADPRO** environment. **RADPRO** also provides another way for editing data more precisely by typing the wanted editing zone.

3) **Utilities:**

RADPRO provides several tools to help the interpretation of radargrams. Currently available utilities are as follow.

Pick Layer: picking travel times of a certain layer.

Resample Traces: resampling data traces and save it.

Trace Interpolation: making the number of traces twice by interpolation.

Hilbert Transform: calculating the Hilbert attributes.

Arithmetic Operation: calculating the simple arithmetic operation of two radargrams.

3. Creating radar reflection images

RADPRO supports various display modes of GPR images including topography. It also provides a wide variety of printing and saving options. The available modes of images are as follow.

- 1) *Wiggle trace*
- 2) *Filled wiggle trace*
- 3) *Bitmap image*
- 4) *Bitmap+wiggle trace mode*
- 5) *Color filled wiggle trace*

Radar reflection images can be saved with two different types of graphic file format; Bit map (BMP) and GIF87A (GIF).

4. Data processing capability

Since memories of **RADPRO** are managed by Windows systems, the quantity of processing data is basically unlimited. If the quantity of processing data increases, however, the program running capability goes down because Windows systems start to use virtual memories. Thus data processing on the computer with large memory is strongly recommended.

5. Input file and data format information

The file format of **RADPRO** is RD4 and extension is fixed to RD4. In order to use **RADPRO**, field data have to be converted to RD4 format, which is the first step to start data processing using **RADPRO**. The RD4 file format is described in Appendix. Following formats of field GPR data file are supported currently.

- 1) *RAMAC/RD3*: RD3 file format of RAMAC/GPR
- 2) *PulseEKKO/DZT*: DT1 file format of PulseEKKO. A header file must be present in the same directory as a data file. The name of the header file must be same as that of a data file and its extension be ended with .HD

- 3) *RADAN*: RADAN file format of SIR system.
- 4) *SEG-Y*: SEG-Y file format.
- 5) *RAMAC/BH (RD3)*: RD3 file format of the old RAMAC/Borehole system.
- 6) *RAMAC/BH (RD5)*: RD5 file format of the directional antenna data the old RAMAC/Borehole system.
- 7) Text file: Text file means a disk file containing the data part only, trace by trace. Four kinds of data types are supported: 1) Binary(32 bits float), 2) Binary (16 bit integer), 3) Binary (32 bit integer), 4) ASCII. Sampling frequency, No of Samples/trace, and Measurement interval(m) are the essential information, so they must be input precisely.