GPR_CMPG

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Description: GPR_CMPG performs a CMP (common midpoint) gather of GPR traces along a single radar line. Each GPR file must contain one set of traces at equal spacing with a fixed offset (common offset gathers). All GPR files for the single line must contain the same number of traces. Once all the files are read and the data are re-sorted into common midpoint gathers, a constant-velocity normal moveout (NMO) correction is performed. A mute is applied. Then the gather is stacked. The CMP stacked section (for the radar line) is saved to disk as the first "grid" in a DZT radar file. The remaining "grids" will be the individual CMP gathers and then the individual CMP gathers after NMO correction and muting.

GENERATING THE CMP STACKED SECTION

For a subsurface model that consists of constant-velocity, horizontal layers, the travel-time curve (from the transmitting antenna to a layer and back to the receiving antenna) as a function of offset (which is the distance between antennas) is a hyperbola. The difference in travel time between zero offset and some other offset is called the normal moveout (NMO). The NMO correction is the subtraction of the appropriate NMO time from every sample in a trace.

A common midpoint (CMP) GPR record is required to perform the NMO correction. A GPR CMP record (or gather) is one in which the each trace in the record is from two antennas that are positioned equally and oppositely from a central point at uniformly increasing distances. When the correct NMO velocity is used, the hyperbolic shape of a horizontal reflector in a CMP record turns into a flat reflector. See Yilmaz (1987) for details.

The GPR files used as input for this program must be common offset files. That means that the antennas have the same separation in each file. In addition, the stations must be spaced the same (for example, 0.05 m between each station in every file) and there must be the same number of stations in each file. The antenna separation (the offset) must increase the same amount from one file to the next, with the first file read having the smallest offset.

After all files are read in, the traces are sorted into CMP gathers, where all traces have the same midpoint. An NMO correction for one velocity is applied to all the gathers with a mute.

Here is the general algorithm used to perform the NMO correction.

- For the selected velocity (m/ns)
   - Square the velocity; $[V^2]$
  - For every trace in a file
     - Calculate the offset (meters) of that trace; $[X]$
     - Square the offset and divide by the square of the velocity; $[X^2/V^2]$
     - For every sample in a trace
        - Calculate the travel time (ns) at the sample and square the value; T^2
        - Calculate the NMO time, $Tnmo = SQRT(T^2 + X^2/V^2)$
        - Get the amplitude values for the samples on either side of the NMO time
        - Linearly interpolate to the get the amplitude for the NMO time; AMPnmo
        - Change AMPnmo to the median value if > the mute limit = $[(Tnmo-T) / T]$
        - Assign the AMPnmo to the current sample

- If every sample has been muted then give a special mark to trace

The input to this program is a "CMD" file, an ASCII text file containing keywords (or commands) which are discussed in a section below. There is no graphic display of the data. To display the converted data, use programs such as GPR_DISP.EXE or FIELDVEW.EXE. If you need to select a subset of traces from a file or change the number of samples per trace then use GPR_SAMP.EXE.

THE KEYWORDS

Following is the list of keywords and their default values. The documentation format is:
"KEYWORD: **keyword** = default value".
Look at GPR_CMPG.CMD as an example command file with correct usage and default keyword values. The file GPR_CMPG.CMD has most comments stripped out, and GPR_CMPG.CM_ has all comments removed.

*************************** PROGRAM CONTROL ******************************
KEYWORD: **batch** = "FALSE"
Place program in batch mode (no pauses) if "TRUE". If set to "FALSE", the program will pause after the keyword values are displayed and ask if you want to continue. After the data are processed, the program will end automatically.

KEYWORD: **display_none** = "FALSE"
Set to "TRUE" to suppress displaying keyword values when program starts up.

**************** SPECIFICATION OF INPUT AND OUTPUT DATA *******************
Recognized storage formats are:
  DZT - GSSI SIR-10A version 3.x to 5.x, only

KEYWORD: **num_input_files** = 0
Replace the 0 with the number of files you wish to process. There must be three or more input files. There is no set limit to the number of files.
Here are some examples; they would all be read in the same.

KEYWORD: **input_filelist[]**
Add an equal sign, =, then list the filenames after the brackets. The list can extend across multiple lines. Input filenames can occur more than once in the input list but cannot appear in the output list (order-wise) after they appear in the input list.

        input_filelist[] = file1.dzt file2.dzt file3.dzt file4.dzt file5.dzt

        input_filelist[] =
                file1.dzt file2.dzt file3.dzt file4.dzt file5.dzt

        input_filelist[] = file1.dzt
                file2.dzt file3.dzt
                file4.dzt file5.dzt

        input_filelist[] =
                file1.dzt
                file2.dzt

file3.dzt
file4.dzt
file5.dzt

KEYWORD: **dzt_outfilename** = ""
This is the output GPR binary data file name that will contain the results of CMP procedures and the
CMP stacked section. This file contains several "groups" of GPR data.
group 1 = the CMP stacked section.
group 2 = the CMP gathers.
group 3 = the CMP gathers with the NMO correction and a mute.
The comment string in the file header notes how many traces are in the section and in each gather. It also
notes the time-zero sample, the mute, positioning information, and antenna offsets. GPR_RHDR will list
the information in the file header.

KEYWORD: **channel** = 1
This is the channel to use in multi-channel data sets. GSSI data can have up to 4 channels (channel = 1, 2,
3, or 4). This keyword applies to multi-channel GSSI DZT files only. Note that output files are single-
channel only.

KEYWORD: **offset_first** = 0
This is the distance in meters that separates the antennas for the first file.

KEYWORD: **offset_incr** = 0
This is the uniform distance in meters the antenna separation is increased for each file.

KEYWORD: **pos_start** = 0
This is the horizontal location in meters of the first trace in every file. It is assumed to be mid-way
between the antennas.

KEYWORD: **pos_step** = 0
This is the uniform separation between traces in every file.

KEYWORD: **samp_first** = 0
This is the sample number that represents time-zero, or the sample at which the transmitter fired. Samples
are indexed from 0 (that is, the first sample at the start of the trace is sample 0).

****************** SPECIFICATION OF NMO PARAMETERS **********************
KEYWORD: **velocity** = 0.0
This is the NMO velocity in meters per nanosecond (m/ns). The valid range is 0.01 to 0.30 m/ns.

KEYWORD: **mute** = 0.0
This is the stretch percentage where muting starts (that is, all samples in the trace are assigned the median
value)
Example: mute = 50 means the maximum stretch, equal to (Tnmo-To)/To, allowed is 0.5.

********************* SPECIFICATION OF RANGE GAIN ***********************
Because signal strength is often greatly reduced at longer offsets between antennas, it is useful to increase
the gain if the traces. The gain below is applied to only a subset of the traces and their samples. The gain
is given as decibels. Sometimes it is useful to have the bottom gain (rg_on[1]) less than the top gain
(rg_on[0]). The gained block of samples can also be slid down each trace to mimic the moveout.

KEYWORD: **rg_start_trace** = 0
Start the gain at this trace (goes to last trace).

KEYWORD: **rg_start_samp** = 0
Start the gain at this sample on first trace.

KEYWORD: **rg_stop_samp** = 0
Stop the gain at this sample on first trace.

KEYWORD: **rg_step** = 0
Move start and stop samples down by this much for every trace after the start trace.

KEYWORD: **rg_num_on** = 0
Only 0 (no gain) or 2 (gain) are allowed.

KEYWORD: **rg_on[0]** = 0
This is the gain for the top sample in the block (**rg_start_samp**). The value is in decibels (dB); 6 dB = 2X; 12 dB = 4X; etc.

KEYWORD: **rg_on[1]** = 0
This is the gain for the bottom sample in the block (**rg_stop_samp**). The value is in decibels (dB).

Usage: GPR_CMPG cmd_filename
Required command line arguments:
cmd_filename - The name of the keyword file.
Optional command line arguments (do not include brackets): none
Examples:
gpr_cmpg gfile1.cmd