Newsletter - August 2017

We would like to welcome the following organizations to the GPR-SLICE community:

- Geoside Geofisica snc, Italy
- Higashi Nippon International University, Japan
- Institute of Archaeology, Monuments and Art History, University of Bamberg, Germany
- Phase One GPR, Florida
- Department of Geophysics Suleyman Demirel University, Turkey
- Impulse Radar, Sweden
- Institute of Archaeology, University College London
- Stadt Essen, Amt duer Geoinformation, Germany
- Sherpa ENC co., ltd., Korea
- Taimyr Georadar, Norilsk, Russian Federation
- Gel Geophysics, Charleston, South Carolina
- Terracon, Oklahoma City, OK
- Umut Basoglu, Turkey
- Precise Locating Service Inc., Altoona, Florida
- Dept of Geography and Anthropology, University of Wisconsin - Eau Claire
- Estudios Geofisico de Occidente, Mexico
- CDM Smith Consult GmbH, Stuttgart, Germany
- Wiley Geotechnical, Mangawhai, New Zealand
- Newcrest Mining, Papau New Guinea
- Archaeological Prospection Service of Southampton, University of Southampton, UK
- BE Surveys, Greenfields, Western Australia

The National Park Service in Tallahassee expanded the number of licenses to 4, the University of Southampton and Terradat in the UK both took an additional license; Murphy Surveys in the Ireland added multichannel licenses to their GPR-SLICE capabilities.

GPRSIM Software licenses were delivered to:

- Wuhan Binhu Electronic LLC, China
- Electronics and Telecommunications Research Institute, Korea
- Phase One GPR, Florida

Software Updates

Among the most important improvements added to GPR-SLICE V7.0 Software are:

- OpenGL XYZ-2D menu synced with multi-radargram 2D menu
- 5 point customized anomaly search
- Absolute elevation and thickness exports for subsurface horizons
- Extraction of X and Y planes from a 3D volume written as separate radargram format with their own information files.
- Overlay bitmap in OpenGL orientation with z coordinate addition

OpenGL XYZ-2D menu synced with multi-radargram 2D menu

Over time we have learned for those that are involved in utility mapping, that they often will make time slices if their data is dense enough. However, often these same surveyors will still use the radar profiles as the means to choose the final locations of subsurface anomalies. In particular for assigning locations to utilities, the apex of hyperbola on the raw radargrams are commonly used. Having a menu that could control the visualization on the time slice with just the mouse cursor engaged on the radargram seems like a new step to help those in the utility mapping.

A new feature available on the OpenGL XYZ-2D menu is the R-sync and the R-2D button. The R-2D button will bring up the Radargram menu and allow the user to select many radargrams and their size to be drawn in the dialog. The R-sync button will just show one radargram to the screen and selective clicking of this button will increment to the next radargram in the list. With the radargram dialog open, any mouse movement over the radargram will automatically show a real-time cursor position and the GPR

track for that radargram on the XYZ plane displays in the OpenGL XYZ-2D menu. The cursor position and the active level of it on the radargram will automatically show the same level on the Z-scan time slice display. The new option will allow the user to quickly see the appearance of the active mouse location on the time slices and x and y plane cuts as well. The GPR track of the active radargram will also be simultaneously shown. In this example, it is a simply x or y line (Figure 1a), but for GPS the GPS track of the active radargram will also be drawn on the Z-scan slice (Figure 1b). As the mouse is moved on the radargram (s), the cursor on the XYZ planes will follow the track and will control the depth of the displayed slices as well. The new option also allows the user to click on a drawing object such as a line or sphere and then have these inserted into the OpenGL Volume Z-scan slice via clicks on anomalies in the radargram dialog.

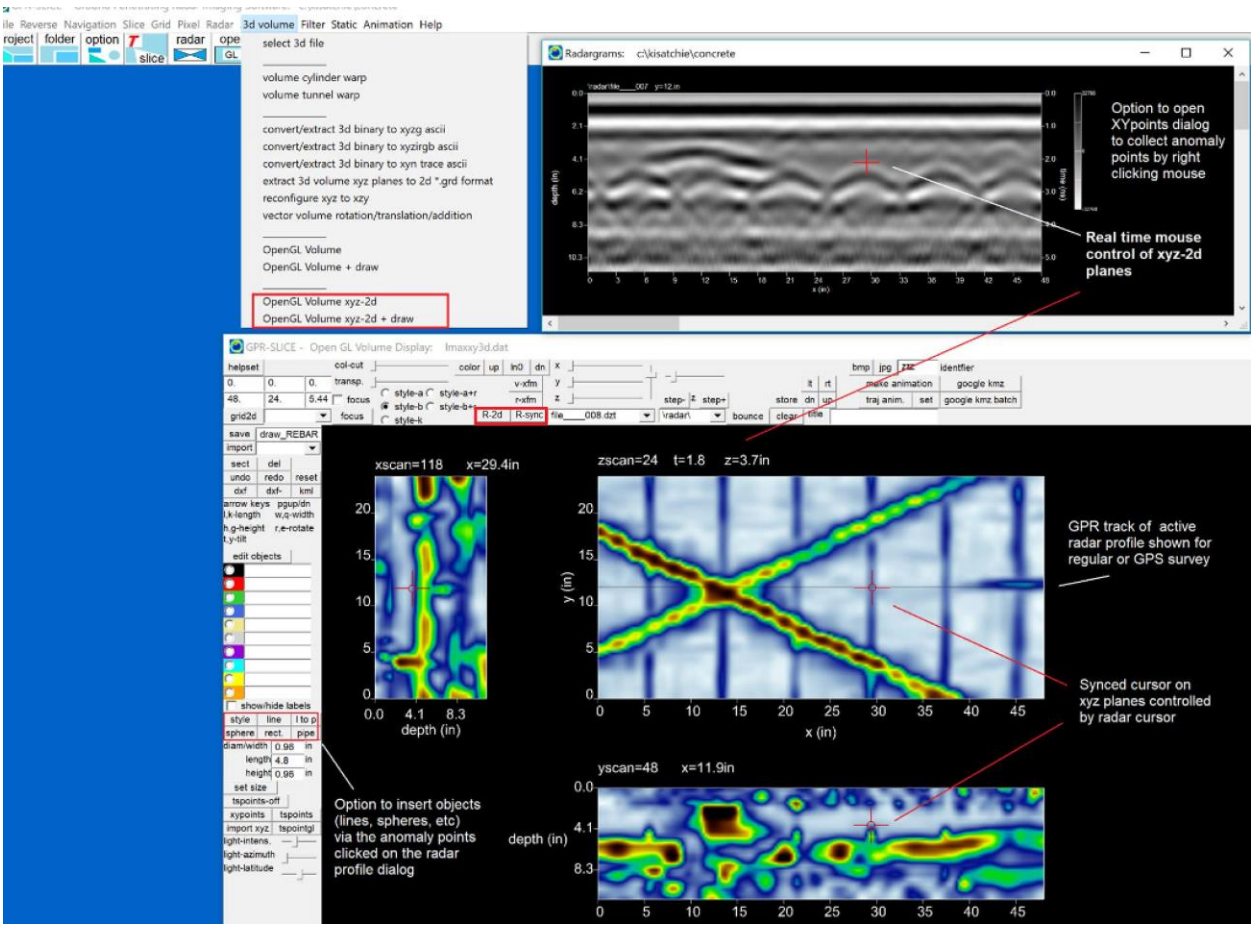

Figure 1a. OpenGLXY-2D and Radargram 2D menu with syncing of XYZ planes and cursor locations controlled by movements on the radargram display for single of multi-radar displays.

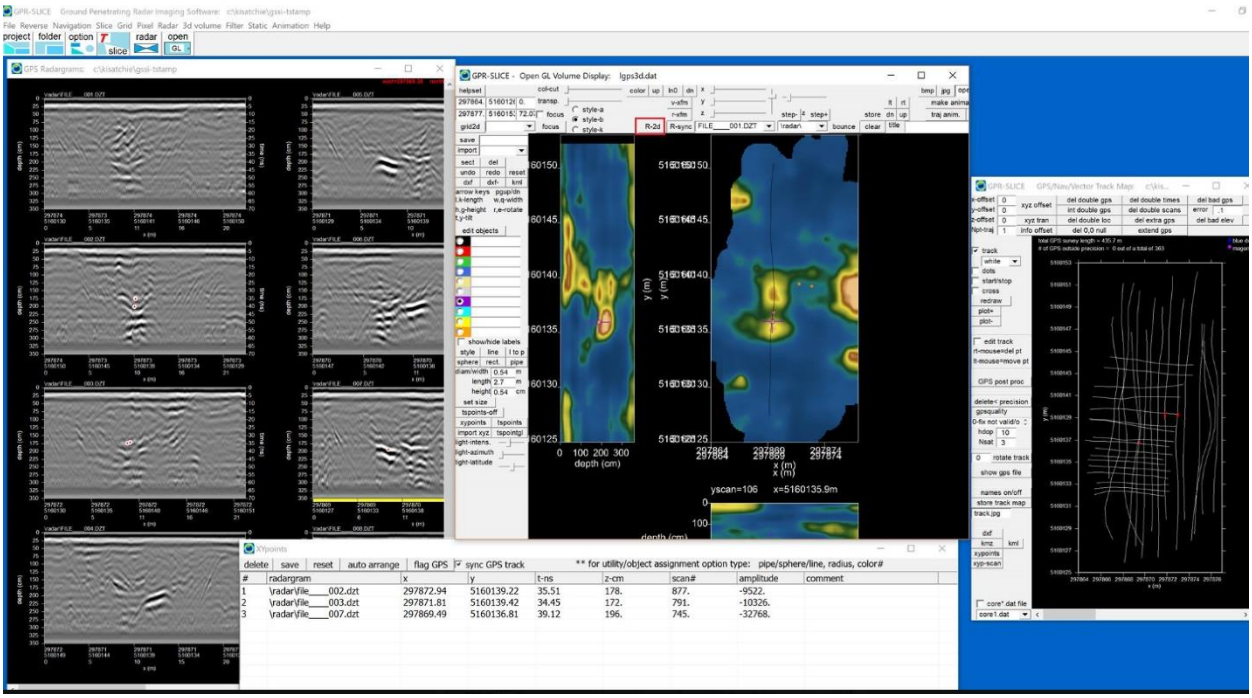

Figure 1b. Example of the new sync operations for multi-radar display with the OpenGL XYZ-2D menu and with the simultaneous launch of the XYpoints menu as well.

5-point customized anomaly auto-search

A new option was added to the Auto Hyperbola Detection module for bridgedeck licenses (Figure 3). The 5-point button added to the Hyperbola Search menu will collect 5 mouse clicks that the user places over an anomaly at varying locations. The relative x,y locations and the binary amplitude of the chosen points on the radargram are stored in the dx, dy and amplitude slots in the menu. Running the Auto Search will apply these user customized points in examining all the binary points in the radargram for detecting hyperbolas. One can experiment what points across a hyperbola that are chosen that will give the best detection. In the example, it was found with this data, that the search algorithm would work optimally when a point on the peak negative part of the pulse, peak positive part of the pulse, a point below the peak positive pulse and two points on the flanks of the hyperbola where chosen.

This new customized option can not only be designed for creating a unique "finger print" to detect hyperbolas, but can be applied to searching any type of observed anomaly observed in the radar profiles. The option is currently available for up to 5 points but we can imagine in a future update to allow more user set points in searching much more complicated anomalies embedded in the radar profiles.

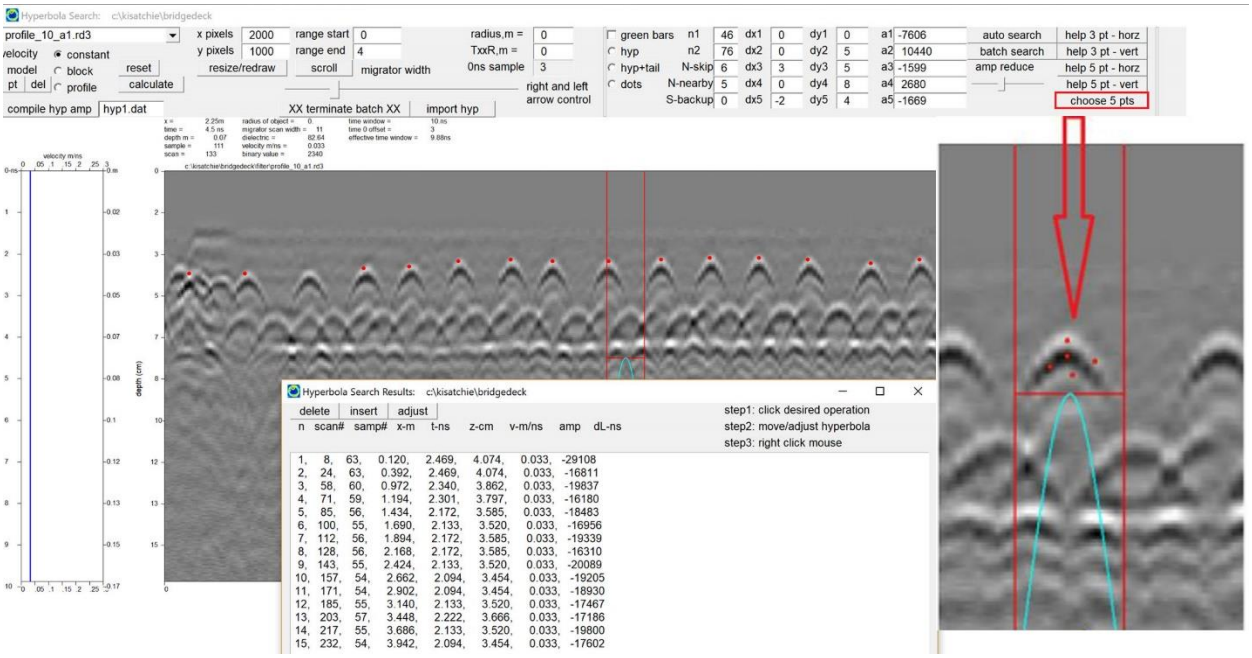

Figure 2. Location of the new 5-point customized anomaly search for bridgedeck licenses.

Compilation of absolute elevation and thickness of detected/drawn horizon layers.

A new option was addeD to output the absolute elevation and the thickness of detected subsurface horizons (Figure 3). Using the Horizon menu, one will detect the ground surface as horizon 1 and a subsurface horizon as horizon 2 and so on. For a topographically corrected radargram, horizon 1 which is the topography over the radargram can easily be replicated using the copy Topo to Horizon 1 button in the Horizon menu. On compilation of the horizon, in this case horizon 2 which is of interest, a new file called horzelev2.dat will be generated. This file contains the absolute elevation of the subsurface horizon and is available for separate gridding in the Grid menu. In addition, another file call horzthickN.dat will be compiled containing the thickness of the subsurface horizon. During the horizon

compilation, additional standard files called horzxyd2.dat are compiled which is the actual relative depth from local surface as well as a separate file containing the amplitude of the horizon. The complete export-horzxytz2.dat file will now have the elevation column for the detected subsurface horizon. (The standard files horizonN.dat contain the sample numbers of the pulse that contain the detected horizon and are the files shown in OpenGL for overlays with time slices, 3D radargrams and isosurfaces).

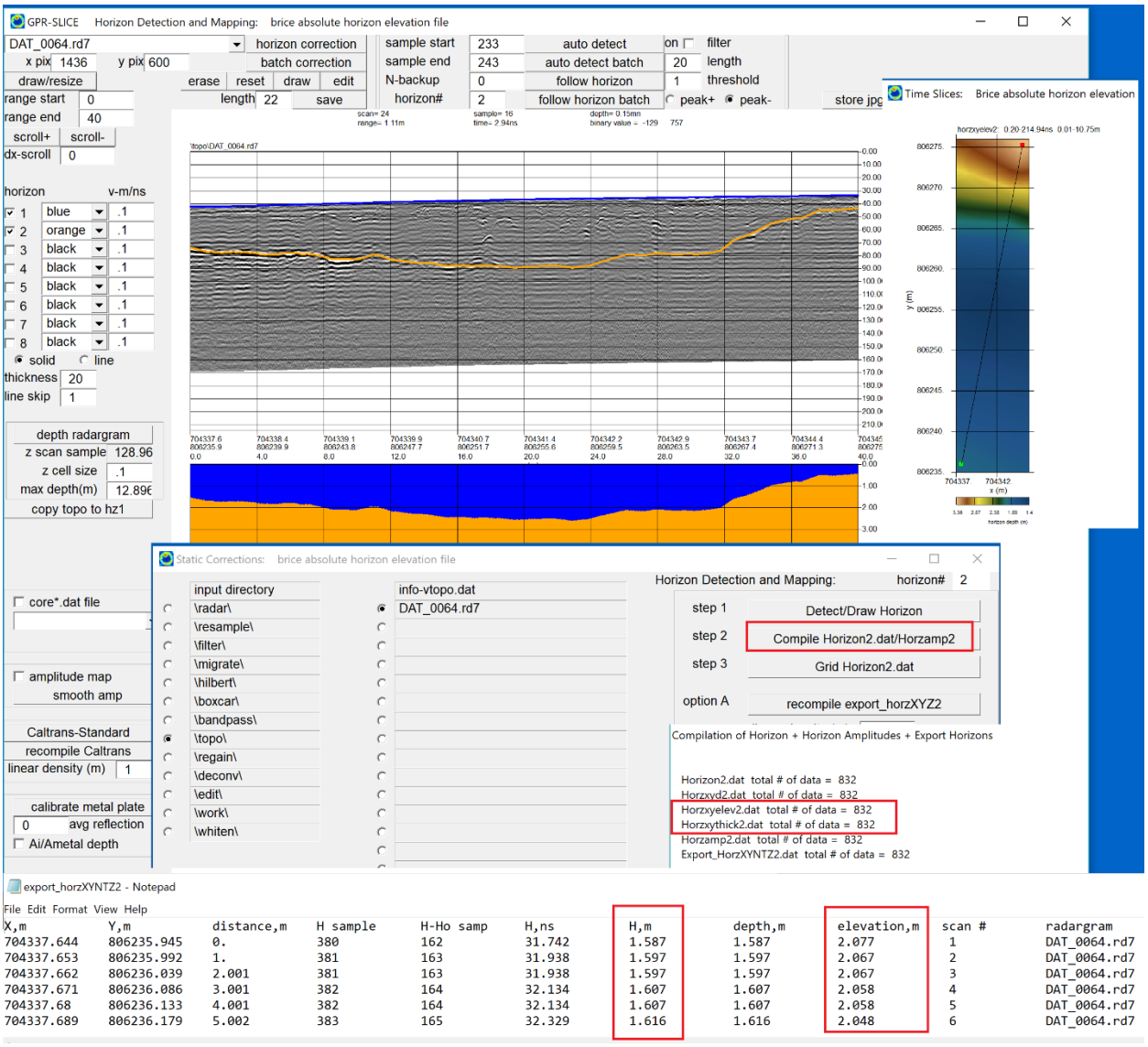

Figure 3. New export options highlighted for detected subsurface horizons including absolute elevation files and horizon thickness files.

Extraction of XY planes in the 3D volume to radargram format

A new option to extract the XY planes in the 3D volume to separate radargram format is available on the 3D volume pulldown menu (Figure 4). Earlier versions of this option converted the XY planes to standalone 2D grid format. The new option allows for all the 2D Radar menu operations to be applied on the extracted x and y radargrams from the volume. Separate information files call info-radx.dat and info-rady.dat are written and the separated XY plane radargrams are written to the \radar\ folder.

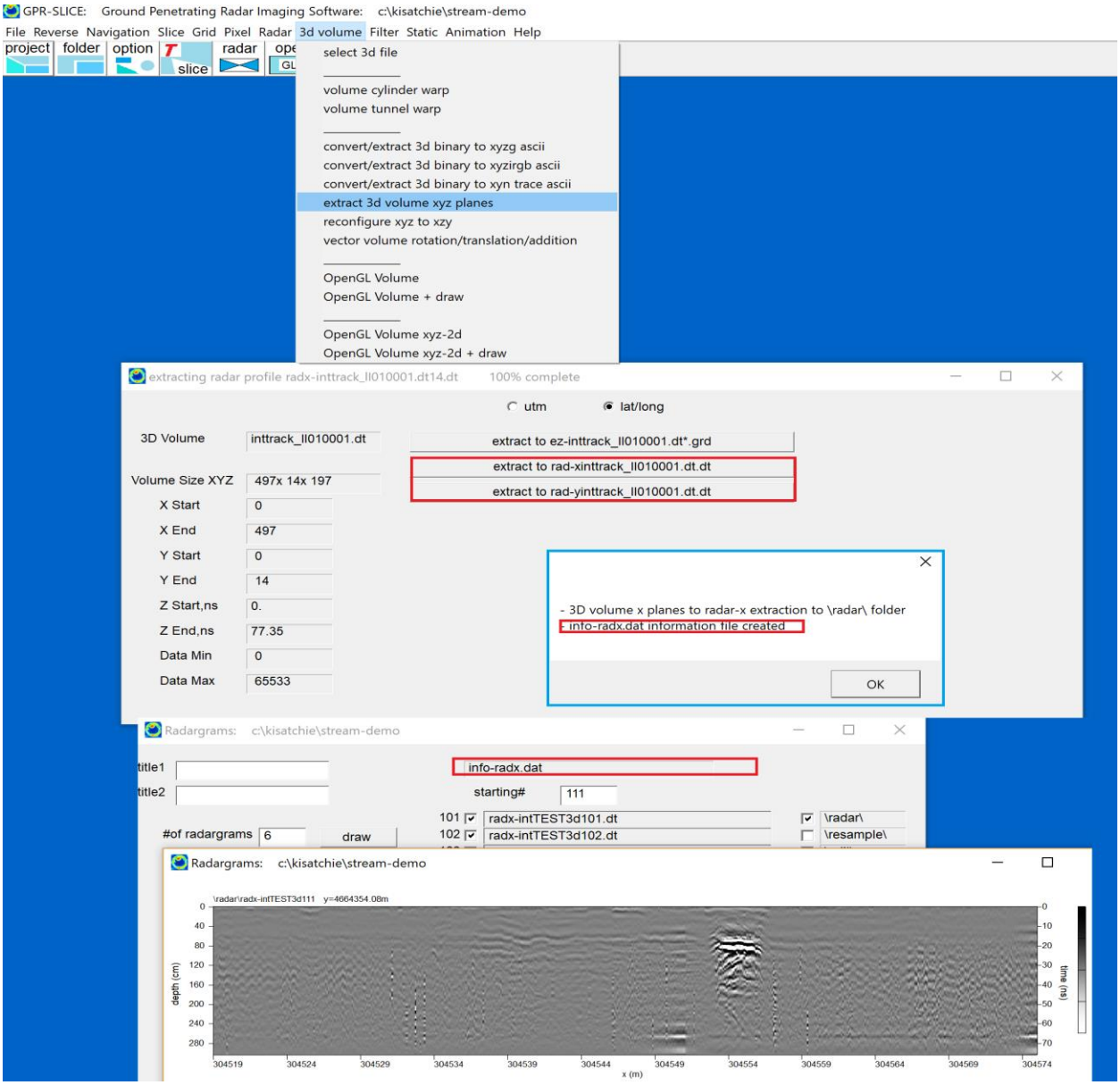

Figure 4. Option to extract XY planes in the volume to individual radargrams.

Artificial navigation must be applied one time to begin using these newly extracted data. This new option is primarily for the Multichannel users where GPS radargrams are being used to generate a volume and they want XY radargram views in addition to the original GPS radargrams. The XY radargram can provide an additional dataset for utility mapping.

Introduction to full resolution imaging for single channel users

A portion of a menu has been opened up to the single channel users groups and allows for full resolution volume generation (Figure 5a). Full resolution refers to preserving the original radar pulse in the compiled volume. These volumes are **not** made from time windowed/interpolated and gridded time slices. Currently 17% of our users have multichannel licenses and these users are generating full resolution volumes in GPR-SLICE. Multichannel gpr surveying will become more prevalent as the cost of these equipment come down as well as the improved engineering on channel balancing continues.

Most of our single channel user group collect data at a variety of different resolutions on the ground. Many will take data at 0.25 - 1m spacing or even coarser spacing of 2-5m and for those working in feet, we often see data spacing of 1, 2, 5, 10 ft spacings are common. For those that are creating 3d volumes from coarsely spaced radargrams, you are normally making 20-30 slices, binning the data at densities slightly less than the profile spacing and making time slices and interpolating time slices and generating volumes. You often can solve a lot of surveying objectives from these coarse spacing and time slicing.

For those single channel users that want to do full resolution they can still use the slice/resample menu and make slices that are almost 1 sample thick and change the bin parameter from abs(amplitude) to simply amplitude. There is a dedicated menu called 3D Radargram Direct Pulse Volume (see Figure 5a). With this menu, one does not use the slice/resample or gridding menus – they simply compile a desired radargram folder directly to a 3D volume! If your data is coarse data, we do not recommend using this menu at all and you should continue to use the slice/resample, gridding and pixel maps menus to generate interpolated volumes. However, for those users that sometimes record very dense – single channel lines and want to generate full resolution volumes of the pulse, this menu is available.

I thought it would be enlightening to show a dataset, where without full resolution mapping on the ground, features can be lost. The dataset below, is provided by Tim Horsley at Horsley Archaeological Prospection LLC

(www.archeopros.com) at the Morton Site (Figure 5b, 5c). Tim collected data with a 200MHz antenna at 20cm spacing on the ground. At this frequency and wavelength, the data can be considered high resolution for the larger wavelengths in the ground at 200 MHz. Tim also used a single antenna and was very careful to control the navigation on the site. For this data, rather than apply time windowed slicing, full resolution capabilities in GPR-SLICE were used to image this data. Shown in Figures 5b and 5c are time slices made from full resolution volumes using only bandpassed radargrams and radargrams that were also Hilbert transformed. The 2 volumes are shown as well as a slice at around 59cm. The pulse volume slice shown indicates a very faint circular feature. This same feature is lost in the full resolution Hilbert volume slice that is also made across a single digitized sample of the enveloped pulse. Time windowed slices made of 4ns at this depth (not shown) are quite interesting but do not have any features that show this very faint circular feature.

There are of course features that are often masked by pulse volumes. You can imagine a line feature that varies in depth and imaged in the pulse volume can change colors from white to black on the feature as the plus and negative parts of the pulse are displayed at a desired depth. Linear features are sometimes more difficult to trace on pulse slices whereas on a Hilbert slice, that feature because we are looking at just the envelope will be a solid color even as the depth changes slightly. However, this faint circle had a slightly different phase then nearby soils that also have about the same instantaneous amplitude. The phase of the signal in this case highlighted the important archaeological feature at the Morton site which transected into the excavation pits and could be identified as wall trenches from an ancient Indian village.

For the example data that was used, the 20 cm line data was compiled at 5cm cells. This left almost 3 empty cells between lines. For this reason, there is an option to interpolate gapped cells between lines. In this case 3 cells were used for Tim's data. Users that do concrete imaging can also try out the direct compilation menu as an alternative to our standard volume generation. For the rebar and concrete surveying, many surveys are conducted at 2-4 inches or 5-20cm profile spacings and have sufficient density on the ground for direct radargram compilation to a 3D volume.

Multichannel users are always making Hilbert and pulse volumes and generally are examining both volume datasets. Pulse imaging has in general been unavailable to single channel users because the distance between lines is too large to effectively map the phase information of the pulse across large distances, unlike the pulse envelop which is easier to interpolate and to synthesize meaningful maps. In any event, this post is meant to start the

introduction for those non-multichannel users or surveyors that do coarse surveying that there are alternatives to search and extract more information from a site. If high resolution profiles within about a ¼ wavelength of the transmit pulse can be acquired at a site, then full resolution imaging with direct volume compilation of radargrams can be effectively done. Data collection with single channel equipment requires more effort, denser data, and more time to play with the data to search all the different imaging options that might be needed to illuminate a feature from full resolution imaging.

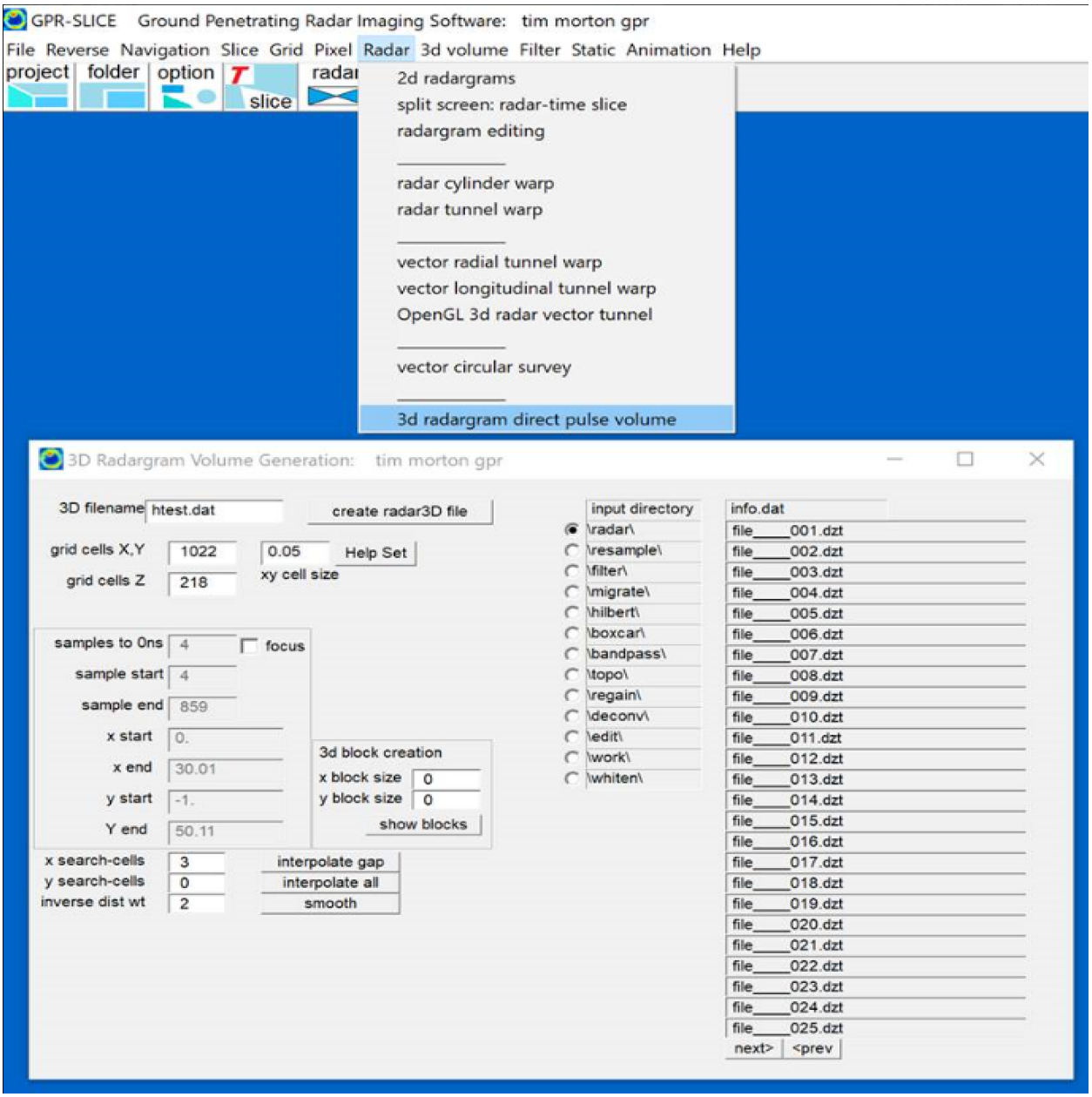

Figure 5a. 3D radargram direct pulse volume compilation menu.

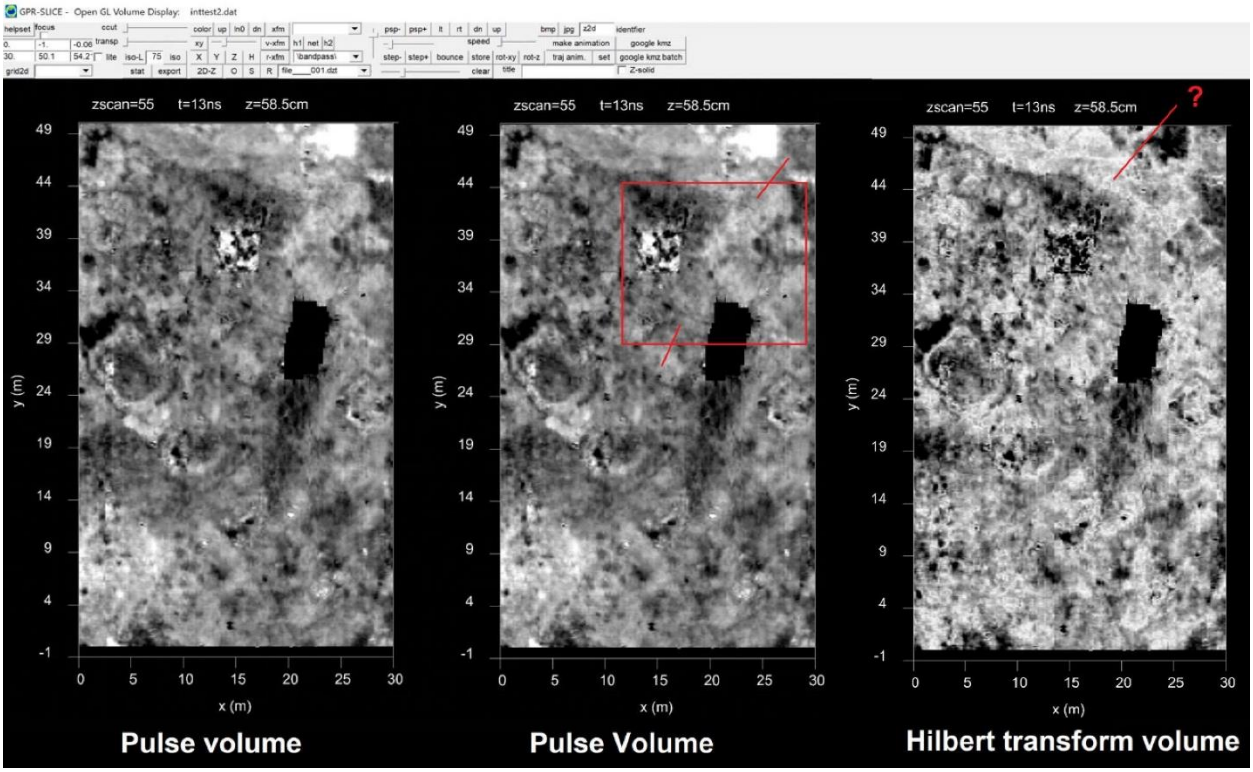

Figure 5b. A time slice comparison of single slices from a pulse volume and from Hilbert volume where the pulse envelop is presented.

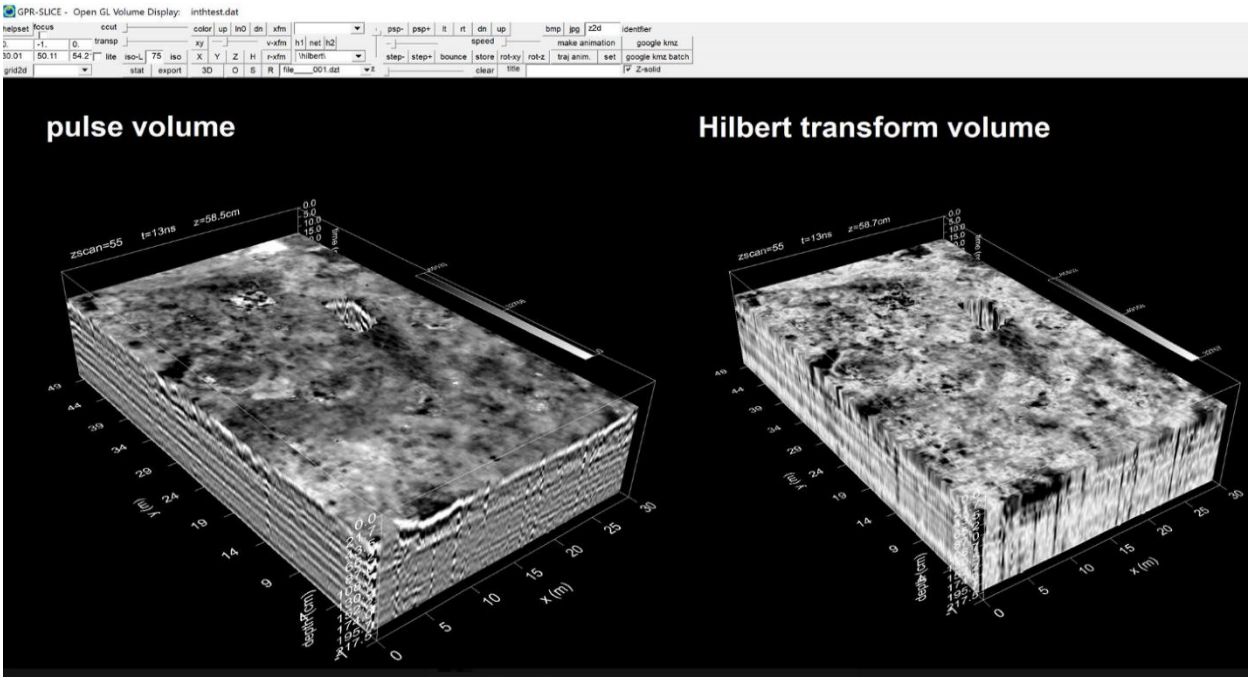

Figure 5c. Comparison images of a 3D pulse volume and a 3D Hilbert volume. Both data have just variable time 0 corrections and bandpass filtering applied. (Data courtesy Horsley Archaeological Prospection LLC).

OpenGL overlay bitmap orientation in 3 dimensions

The overlay of an external bitmap for insertion into the OpenGL Volume now as full 3-dimension capabilities with the addition of the z coordinate in the bmp image overlay menu (Figure 6a). A spectacular example of the use of this new option was made by Dr. Gianluca Catanzariti with 3D GeoImaging – Italy, on a historical building in Turkey (Figure 6b). Using the Vector Addition menu on the 3D Volume Pulldown menu, Gianluca synthesized a single vector volume from a GPR survey made on 2 opposite faces of a support column. His imagery shows continuous structural arch features through the stone structure which can be traced on both sides using transparent rendering. The vector volume is shown in conjunction with a vertically oriented bitmap overlaid in the OpenGL Volume menu utilizing the new option to place a bitmap in any orientation in this menu.

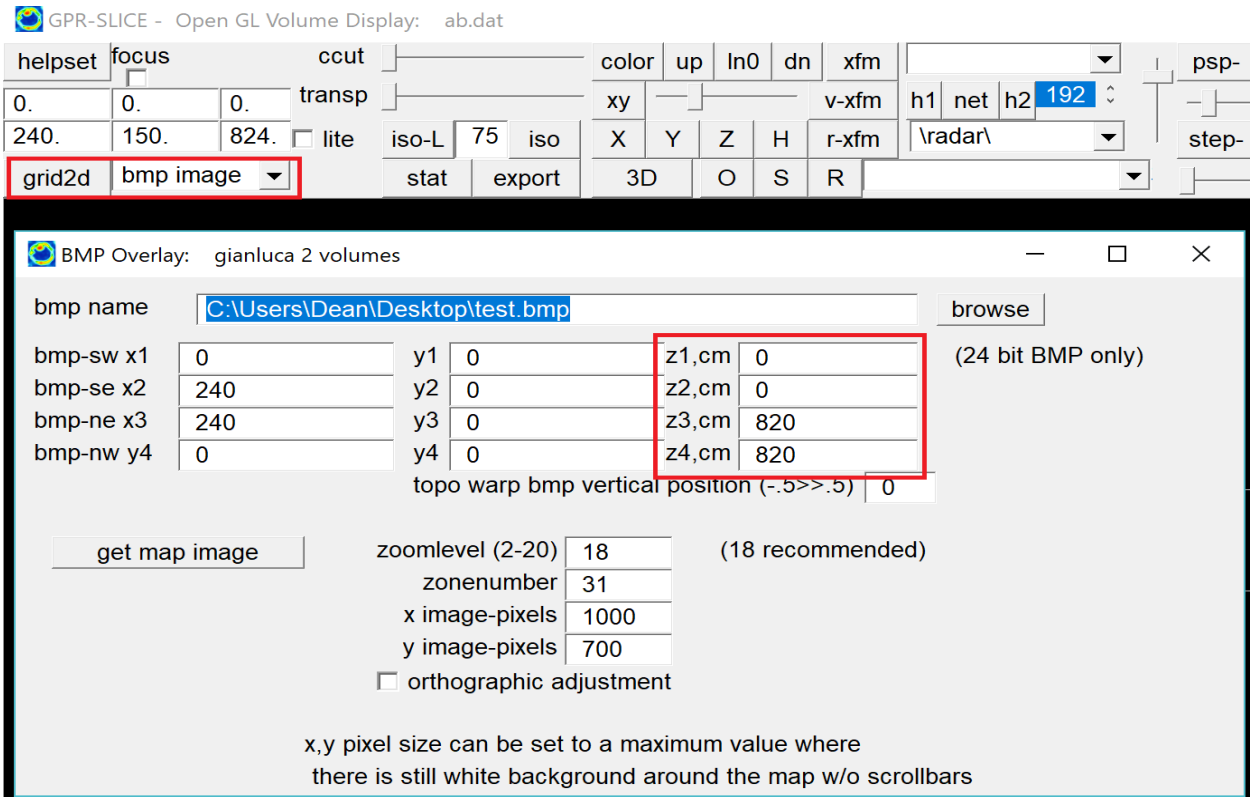

Figure 6a. Addition of the z coordinate in overlaying a bitmap in 3 dimensions in the OpenGL Volume menu.

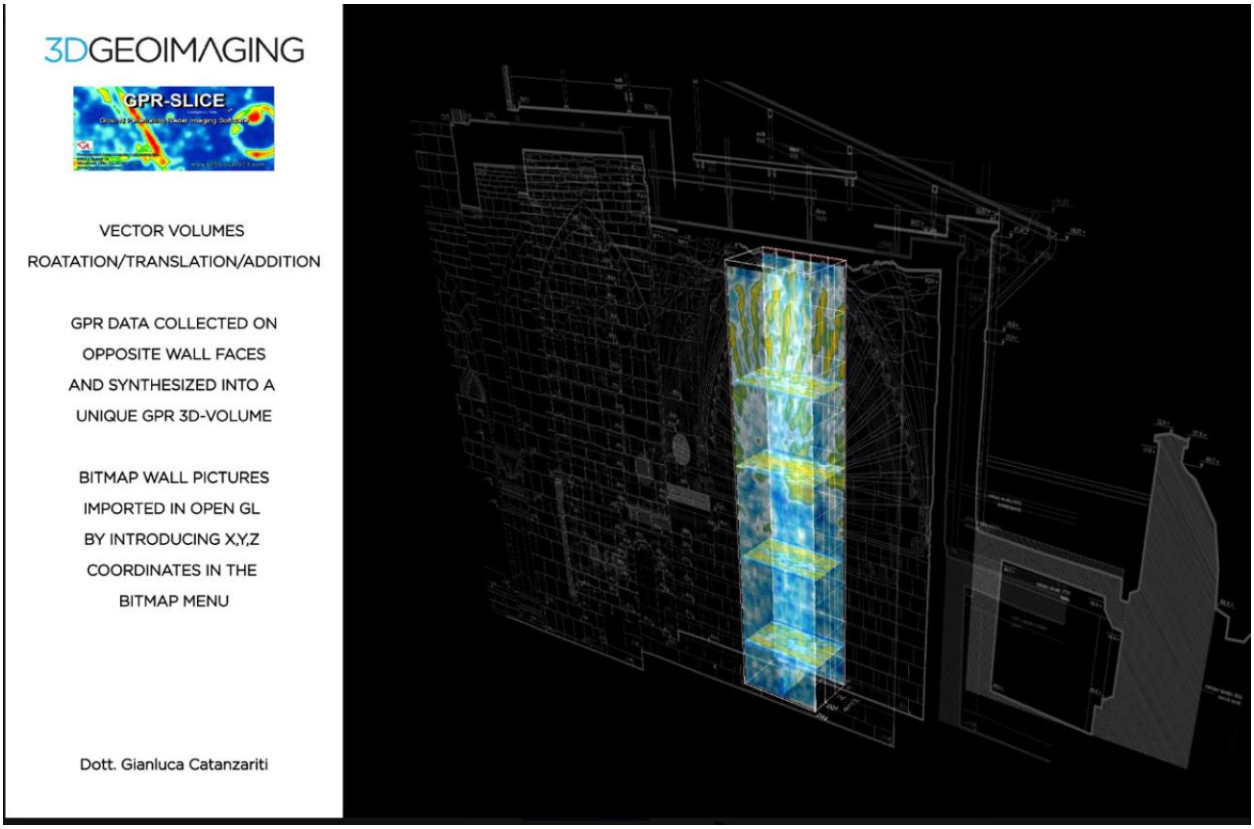

Figure 6b. Example of vector volume addition of GPR surveys made on 2 sides of a structural column with a vertically oriented bitmap, courtesy of Dr. Gianluca Catanzariti, 3D GeoImaging - Italy.

Other features and options added to GPR-SLICE include:

- Extraction of XY planes from 3D volume now written as regular radargrams with their own associated information file - allowing anomaly picking on this dataset in the Radar2D menu
- Maximum direct 3D radargram pulse volume compilation increased to 625mb without slower disk writing
- NGGA$ inertial navigation + gps NMEA string support added Create New Info menu.
- Option to read in reverse file information and apply survey wheel calibration from set baseline on each side of a survey site with the manufacturers ### get XY button
- Applied spectra range gain curve output to dat file in the \bandpass\ folder
- Sitemap bitmap overlay z axis reoriented so that 0 depth is the bottom of the volume and +depth is the volume top

- US Radar version 3 GPS log file support added to Edit Info File menu
- OpenGL Volume 10 object colors reset to match the first 10 standard autocad colors for DXF output
- Sensors and Software *.gp2 GPS format added.
- Convenience buttons added to replicate channel 1 navigation to channel 2 navigation for IDS Opera Duo and Leica D2000 equipment
- Library zip file updated for importing Google Earth bitmaps in OpenGL for HD screen sizes - 3840x2160
- Del Min GPS button added to Edit Info File menu to remove files that do not have a user set number of GPS listing
- Z coordinate included in positioning an external sitemap.bmp
- Inidividual radar track overlay available on the Grid 2D button in OpenGL
- Improved horizon surface lighting option in OpenGL and choice of 256 colors from the active horizon color table
- Triple point Meshlab ascii export for grid files added to Grid menu
- SEGY read enhanced to import arc-second source xy trace header for GPS navigation - requires setting new scalar value for division in the Edit Info File menu to 3600
- New operation to apply the channel calibration gain curves to radargram folder and rewrite these calibrated and regained radargrams to the \regain\ folder for multichannel datasets
- Beta depth color thresholding button added to the Pixel Map menu - to display amplitudes above a user set threshold over n windows on a single time slice - where the number of grids to displays equals the number of divisions in the color table versus depth
- Slice_Windows_Information.txt with time slices filenames, time windows and depth windows written to project folder after slicing operations
- Core locations shown on GPS Track menu
- Similarity volume filtering adding to the Filter 3D menu primarily for multichannel - pulse volume datasets
- New separate library files zip update available for new GIF exports made from extended jpg frame animations
- Real time scan# displayed on GPS radargram corresponding to the mouse position
- Radar Portal of Australia multichannel BlueBox Batch operations added
- Imported sitemap bitmaps that are custom drawings or Google Earth map bitmaps in OpenGL Topo Volume Warp can be drapped over the topography grid
- Mousewheel velocity control in the Hyperbola Search menu along with migrator width control set by left and right arrow
- \nmo\ folder renamed to \whiten\ to allow separating bandpass filtering operations from spectral whitening

- 3D Radar multichannel conversion upgraded from 16 to 32 bits
- Flagged GPS scans accessed conveniently via XYpoints operations reading consecutive GPS listings to set flagged scans in column 13 of the GPS files and removing these scans from 3D radargram volume compilation.
- All conversion dialog menus converted to synchronous operation - keeping the processing dialog on top of the convert dialog and preventing accidental adjustments to the active gain curves
- Core layer names placed in annotation option in OpenGL Volume Draw menu. Mala Mira Extract button moved to the Edit Info File menu
- GIF file export in the Animation menu
- Bandpass+Gain added to RSP Batch and BlueBox Batch Runs
- Automatic import of GSSI Structure Scan Mini grid#.dzx 3d navigation file in the Create New Info File menu
- Slice/xyz or Slice/resample/xyz BlueBox Batch Run radio button option added to the Slice/Resample menu
- GPR-SLICE animation menu and export animation menu speed slider bar added

Facebook Forum

The Facebook Forum for GPR-SLICE is a useful resource for finding more in-depth answers and discussion on relevant GPR-SLICE software topics. If you have not yet joined the GPR-SLICE facebook page, I would encourage you to do so at:

https://www.facebook.com/groups/gpr.slice/

All the discussions in this newsletter were first introduced in Facebook and were simply re-posted here as a service for those in our user group that still have not joined the GPR-SLICE Facebook group.

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