Processing of Raptor 3D GPR Data

In the previous notes, we've covered a few steps concerning the cleaning up of geometry and the loading of raw GPR array data. In this note, we'll deal with some necessary processing steps before data interpretation.

Raw data

Figure 1 below shows the raw data from one section of a project. The lower image shows the data with an overlay of the geometry. This data set is by no means ideal. Firstly, there are quite some gaps in the data. Secondly, and more striking, is the inconsistent coverage, with different orientations, collection patterns, and overlapping data. Some filtering has been applied in the form of a dc-removal filter, and a threshold level for time-zero alignment. We'll see now how it looks after a few simple steps.

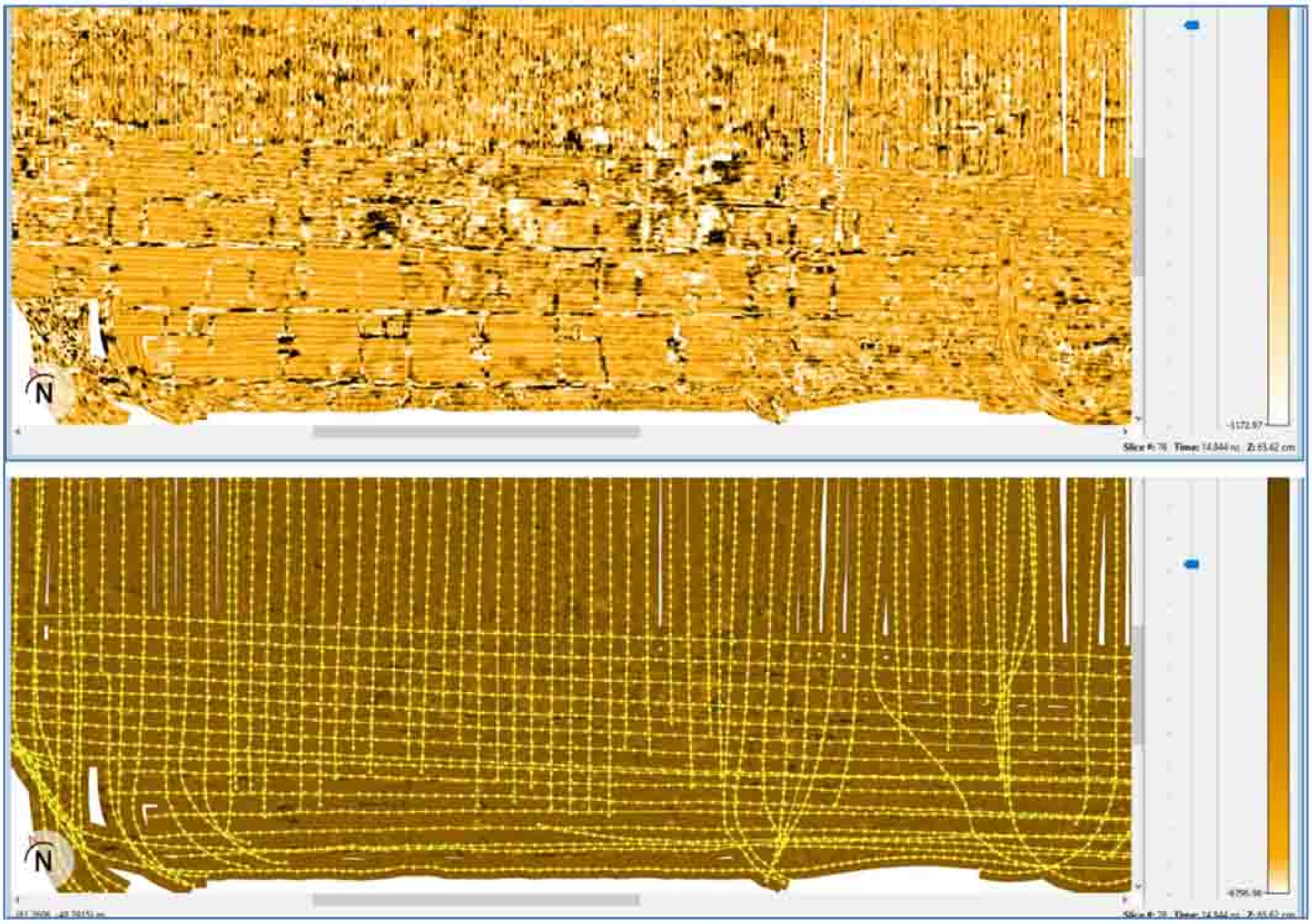

Figure 1, Raw data (top) with geometry overlay (bottom). Note the crisscrossing of lines and non-symmetrical coverage

Step 1 – pre-processing

Figure 2 shows the available pre-processing routines, of which the following three are the most commonly used.

- Antenna ring-down (500 traces in background removal)
- Bandpass (170 – 600 MHz)
- Amplitude correction (spherical divergence correction with no parameters)

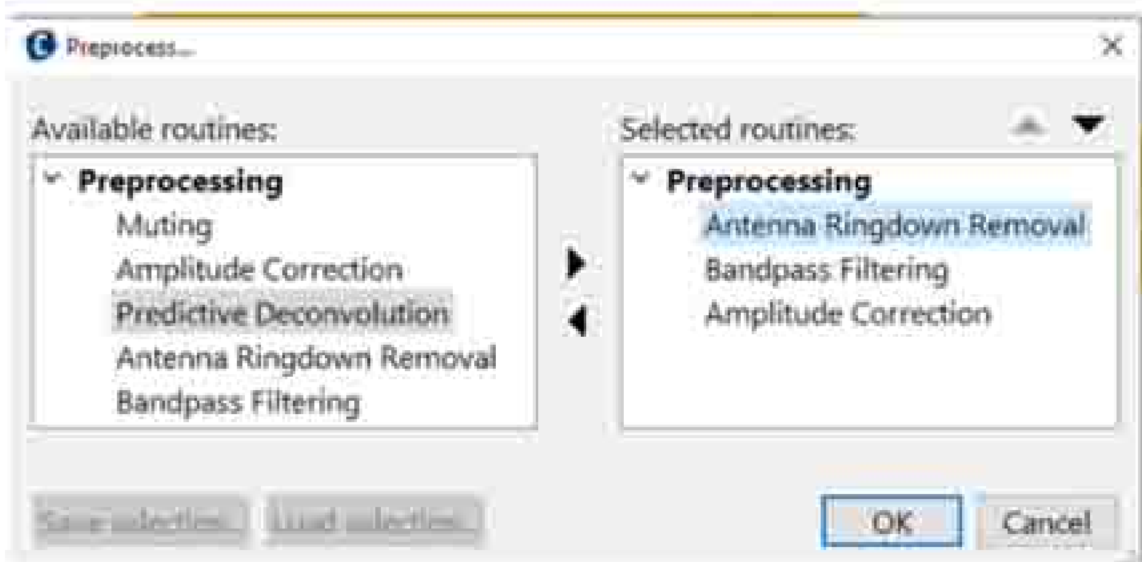

Figure 2, Pre-processing routines

The defaults for each routine are well defined, so there's usually no need to change settings, just select and run.

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The effect of these basic pre-processing routines is shown below in Figure 3. In this case, one may think it's possible to start the interpretation here. However, we're only viewing a single depth slice now, and deeper ones may be much more blurred. Thus, we recommend continuing to the post-processing.

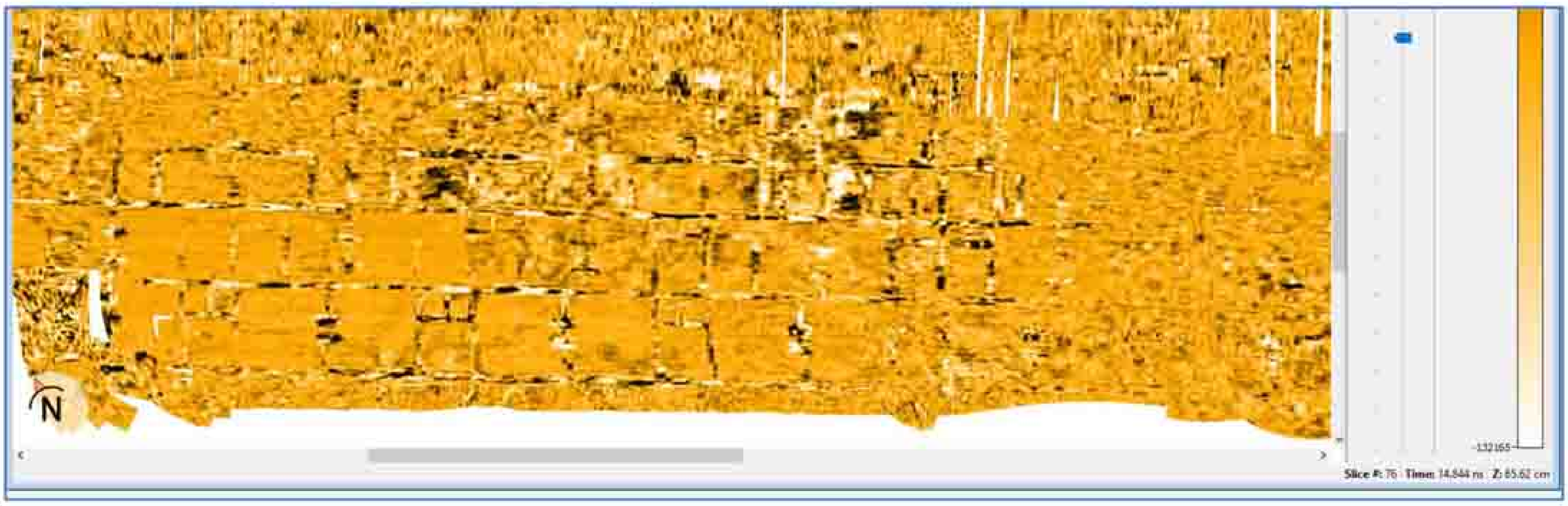

Figure 3, Top view after pre-processing with background removal, bandpass and amplitude correction

In the original data from Figure 1, linear (humanmade) features were visible, but the pre-processed data in Figure 3 represents a significant improvement. Striping in the data is gone, and most features are more apparent.

Step 2 – Regularization/ interpolation

To this point, only 1D and 2D routines have been used. To apply a 3D-migration routine, we need to interpolate the data into regular bins (the size of which (4 cm) was selected when loading the data). At this stage, gaps are also filled by interpolating data from adjacent points.

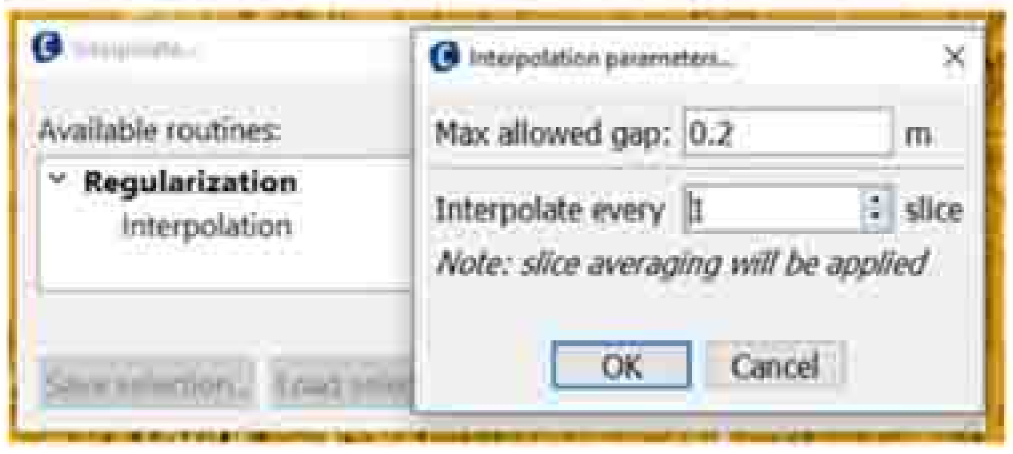

Figure 4, menu for selecting interpolation parameters

Figure 4 shows the options for the interpolation routine, including the maximum gap the software will attempt to fill. The rationale behind this parameter is that there's no use in trying to fill in significant gaps with any interpolation algorithm, as it won't work if the gap is too large. Then we also have the option of slice averaging, which may save some significant disk-space. Figure 5 shows the result after interpolation. *Note* – this stage is usually the most time-consuming routine applied to 3D-data.

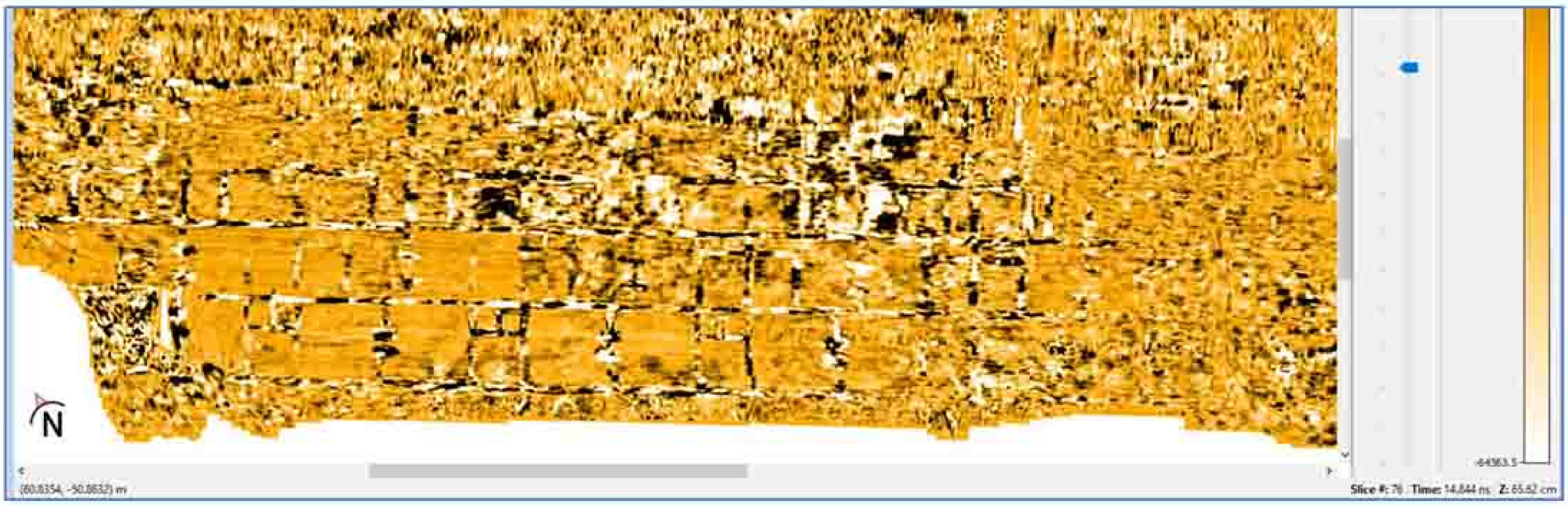

Figure 5, the result after the Regularization/interpolation stage

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Migration and post-processing

Migration is the process during which hyperbolic anomalies are collapsed into points with the help of a known velocity and a selected algorithm. There are a few mathematical algorithms to choose from, each with their pros and cons. However, the key to dealing with 3D-GPR data is to apply a true 3D-migration after interpolation. The alternative is to use 2D-migration and then interpolate the migrated profiles into a 3D-volume, but this approach does not give the same excellent results.

When applying migration, we need to know to which velocity. Instead of guessing, we can use an interactive tool to select the optimal value, and that process will be discussed later in a separate technical note. For now, we jump directly to the post-processing stage.

Figure 6 shows the available post-processing routines, the majority of which will be discussed later in a separate technical note. For now, we concentrate on the commonly used Amplitude Envelope.

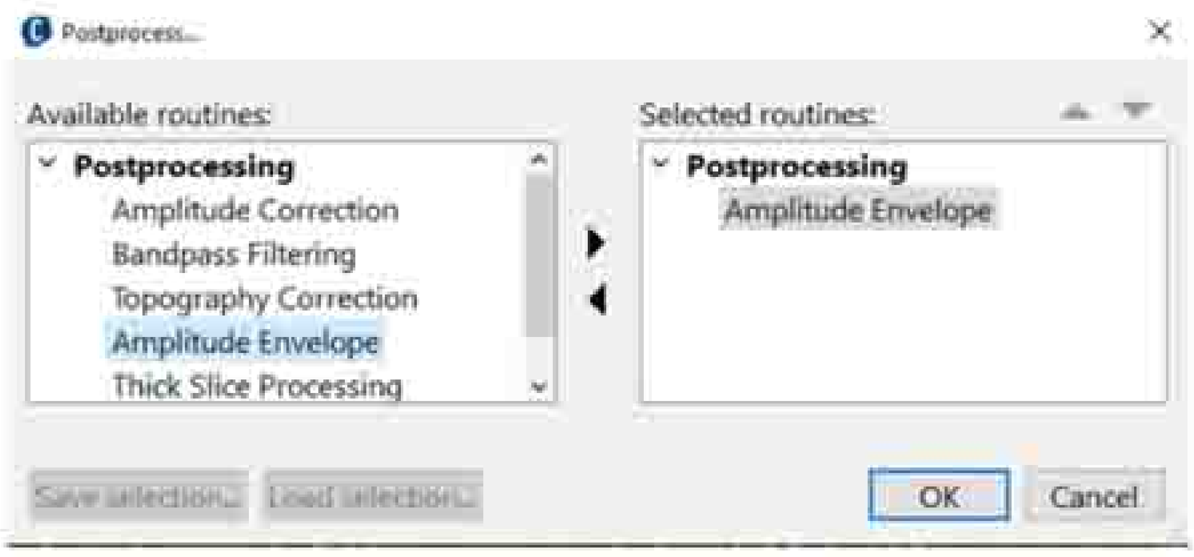

Figure 6, post-processing routines

Amplitude Envelope is the process of applying a Hilbert transform to the data. In simple terms, this effectively moves negative data values over to the positive side and draws lines between peaks. It may reduce resolution slightly, but this is generally acceptable due to the more straightforward interpretation that follows.

Of course, in modern software, a user can always jump between the different processing stages to make use of higher resolution available in other data instances, although this is rarely needed.

Figure 7 displays the impact of migration and the post-processing routines on the working data example. Following a few simple processing steps, we now have data that is much easier to interpret. Again, this is only one depth-slice, so scrolling through the entire depth range, will reveal all targets.

Figure 7, migrated, and post-processed data (at the same depth as in previous figures)

Takeaway

Modern and interactive processing software makes Raptor 3D GPR data easy to manage. You don't need to be a scientist; just follow a few simple guidelines, and the resulting data is significantly more straightforward to interpret than ordinary 2D GPR data, and the ambiguities are gone!