Well Log Extrapolation

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Well Log Extrapolation: an extension to acoustic impedance inversion

Well-log extrapolation is a simple tool to extend horizontally a well-log into the neighborhood of a well.

Well-log extrapolation uses seismic time, or depth sections, as interpolator operator.

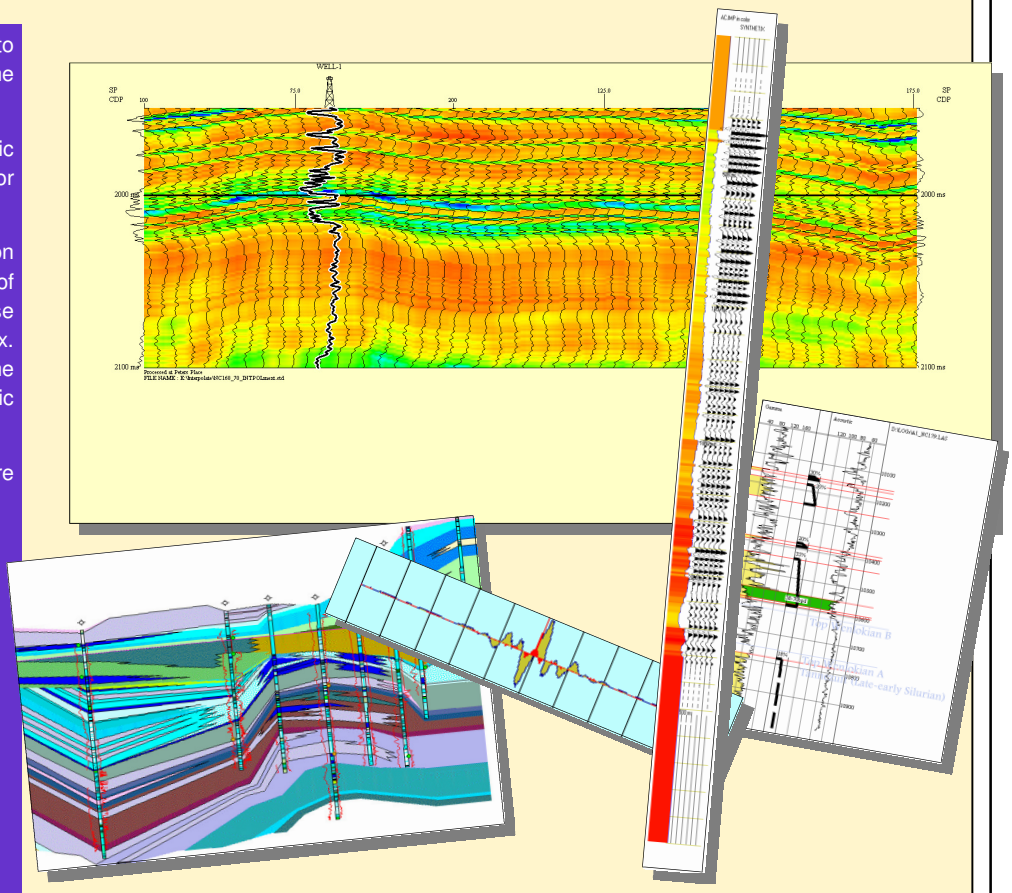
Well-log extrapolation can be based on one single well. This case the validity of the result is limited to the close surrounding of the well location, approx. 2 to 5 kilometers, depending on the quality of the intersecting seismic section.

It can also be based on two, or more wells. This case the computation goes into a “learning” process first, which will significantly increase the reliability of the results.

When it is based on two or more wells, it can include several, intersecting 2D seismic sections, connecting the wells. At the seismic line intersections pseudo log curves will be created, to enhance the stability of the process.

Well log extrapolation works extremely well on 3D data, where the “mistie” problem of the 2D line intersections does not create unwanted phase shifts and artifacts.

By theory, the input seismic data should be “migrated” time section, processed in preserved amplitude mode. In practice any kind of “migrated” time section might do, with the condition that the amplitudes were not totally killed by strong AGC, or other amplitude equalizing disasters.



The conventional “Geological Cross Section” plots are limited, when someone wants to enter into small details. The reason is the “sampling rate”. The popular rule tells that you have to take at least two samples from every wave, when you try to digitize a curve.

The log curves have rather high frequency content in the depth direction, but the sampling rate is also high, so there are no sampling rate problems within the log curve itself.

The trouble starts, when you try to move horizontally, between two wells. The distance is so large, that there must be several “waving” in the log value, until you arrive from one well to the other. A fortunate case is, when you can “flatten” on a characteristic event. This case you don’t expect too much change along the “flattened” event, which means, sampling at the two well locations are more than enough. Unfortunately you can not flatten on all existing layers, and anyway, you do expect some changes between the wells.

There are always some very small elements everywhere, what you should be able to use for the magical “flattening”. The solution is to use the seismic wave, as interpolator operator. The seismic wave “knows”, what went on when it visited the deep layers in the earth. Just let it work for you.

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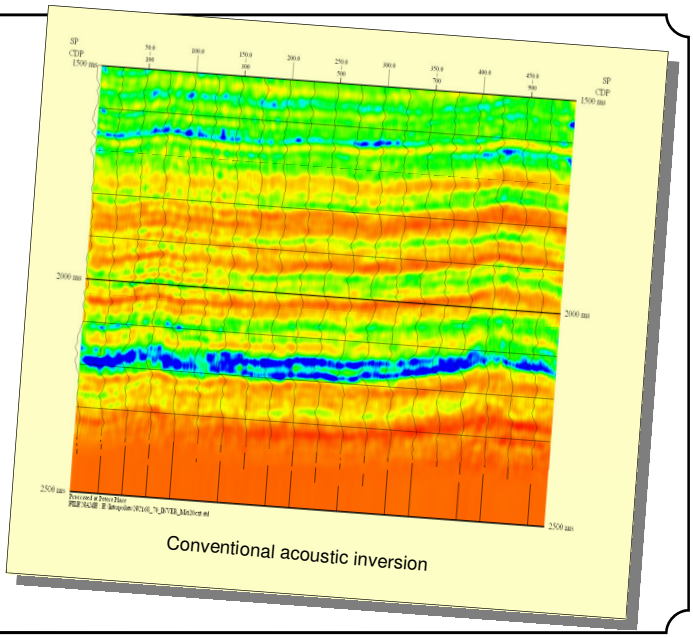
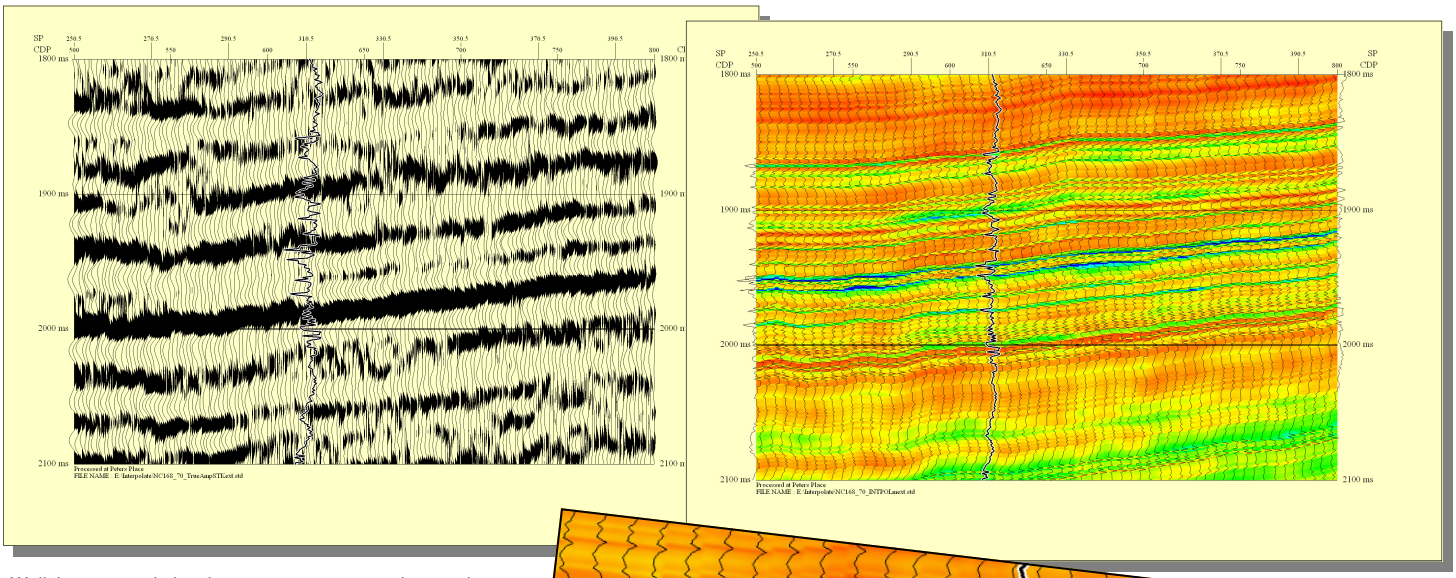


Conventional acoustic inversion

There are a few things, what you have to take into consideration. The seismic wave and the sonic log are the two items, which belong to the same “family”. So, you can expect that the seismic wave “knows”, how the sonic log curve should behave between two wells, but it might be difficult to use it for the prediction of other types of logs, such as the gamma ray log. Also, you have to see that the “inverted” seismic section (called sometimes as acoustic impedance section) is a closer relative to the sonic log, than the original seismic. The original seismic is in fact a relative of the changes in the acoustic impedance, a few steps away from the sonic log itself. For this reason it is better to use the “inverted” seismic section, as interpolator function.



Well log extrapolation is an easy way to enhance the resolution of the seismic time sections. The two images above show the same seismic time section piece. The conventional time section is on the left side, to the right there is the extrapolated sonic log section. The resolution of the extrapolated section is nearly as high, as the resolution of the original sonic log.