Nonstationary colour correction in ProMAX

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ABSTRACT

We have recently upgraded two ProMAX modules, **Gabor2** and **Gabor_sc** to allow the **"white spectrum"** assumption, conventionally adopted to enable the deconvolution of seismic traces, to be replaced with a **"coloured spectrum"**, whose characteristics have been derived from analysis of a reflectivity log located near the seismic survey. The result is seismic data whose bandwidth and phase more nearly represent that of the local earth reflectivity, and thus tie better with well logs.

INTRODUCTION

As shown by Cheng and Margrave (2008, 2009 CREWES research reports), the magnitude spectra of reflectivity logs constructed from actual well logs differ significantly from the flat, **"white"** spectrum usually assumed for them, often being significantly **"blue"**—that is, with higher amplitudes at high frequencies. Furthermore., the "colour" varies not only in **frequency**, but also in **time** (nonstationary). Cheng and Margrave also showed that the slow variations in the well log frequency spectra can be represented by low-order **polynomial curves**, whose coefficients are derived by least-squares fitting of well log amplitude spectra to the curves; and they implemented MATLAB software to do the **well log analysis** and **coefficient extraction**. The output of this code is a set of polynomial coefficients for each of a family of overlapped analysis windows applied to the well log. This set of polynomial coefficients can be used to evaluate a **2D "colour function"**, which can then be inserted into the Gabor deconvolution operation to replace the "white" assumption.

Cheng and Margrave also showed convincingly that nonstationary deconvolution using "colour correction" provides superior deconvolution results, in which the **deconvolved seismic traces** better match not only the **frequency spectrum** of the well log, but also the **phase** of specific **reflection events.**

Because of the promise of this technique, we implemented it in both ProMAX Gabor deconvolution modules, and we illustrate some of the features of those modules here.

PROMAX SPECIFICS

Since the log **reflectivity analysis** procedure is already established in MATLAB, we chose to modify this software to output an **ASCII** file containing five lines of **header** information (identifying the well and its analysis parameters), followed by lines of numerical values, one line per analysis window, which contain the analysis window **start time** and the **polynomial coefficients** for whatever order of polynomial was selected to fit the spectra. This **ASCII** file then becomes an additional input for **Gabor2** or **Gabor_sc**, from which they reconstruct the **"polynomial spectra"** internally.

Both ProMAX modules feature a new switch parameter in the menu window. When **"Apply colour correction"** is selected, five more parameter lines appear in the menu window, as shown in Figure 1, one of them showing the **pathname** for the ASCII file which will supply the polynomial coefficients, the others specifying the **number** of analysis **windows** used on the well log, the **time shift** from analysis window start to window centre, the **order** of the polynomial curves, and a **normalization** coefficient.

While both Gabor2 and Gabor_sc reconstruct the 2D colour function and use it to modify the resulting deconvolution, Gabor_sc also has the ability to output the colour function as a trace ensemble which can be plotted in gray-shade or colour, as a diagnostic.

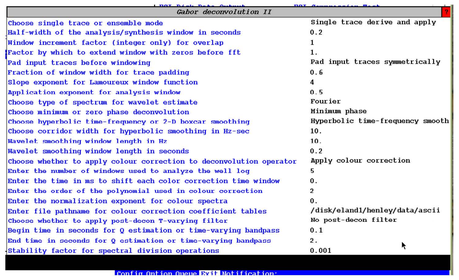

FIG. 1. The menu for the updated version of Gabor2. When the parameter 'Apply colour correction is selected, the following five parameters must have entries. When 'No colour correction' is chosen, these parameters are hidden. The menu of Gabor_sc is similar, except that when the diagnostic mode is chosen, the colour function may be selected for diagnostic output, as an alternative to one of the Gabor spectral components.

Example 1: blue spectrum, no temporal colour

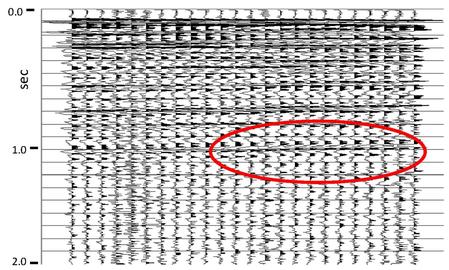

FIG. 2. This group of traces has been deconvolved by Gabor2, with no colour correction, so the normal "white" spectral assumption has been applied to the deconvolution

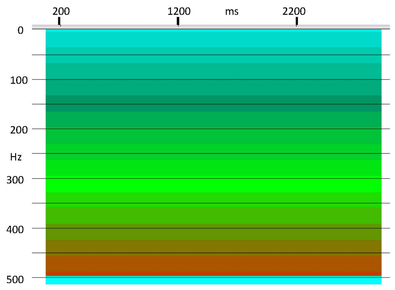

FIG. 3. This is a synthetic colour function of polynomial order 2 in frequency, whose magnitudes increase with frequency. There is no temporal variation—so this spectrum is "blue" in the frequency dimension , but "white" temporally. (Note that the colour scheme of the plot is red=high magnitudes, blue=low magnitudes.)

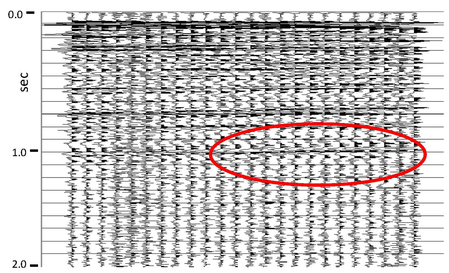

FIG. 4. This is the same group of traces as shown in Figure 2; but these traces have been deconvolved in Gabor2 with colour correction applied, using the colour function shown in Figure 3. The traces are noticeably broader in band than those in Figure 2, and some small phase differences for specific reflections can also be seen

Example 2: spectrum from well reflectivity log

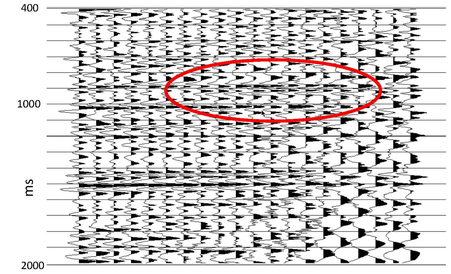

FIG. 5. This set of traces has also been deconvolved by Gabor2, with no colour correction.

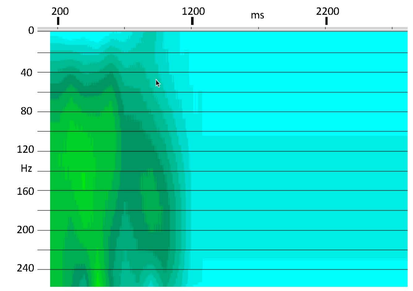

FIG. 6. This 2D colour function has been constructed from the spectral analysis of an actual well log reflectivity series. Note that this colour function exhibits non-white "colour" in both frequency and time. Since the well log itself extends down to only a little more than 1000 ms, the function has been extrapolated for deeper times.

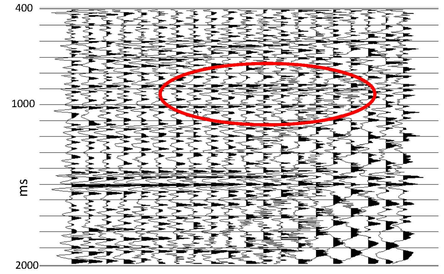

FIG. 7. This is the same set of traces as shown in Figure 5, but deconvolved with Gabor2 using the colour function in Figure 6 to apply colour correction. The differences between these traces and those in Figure 5 are more subtle than in the previous example, but significant, nevertheless.