Square Root Arithmetical Mean of the Amplitude in multi seismic survey processing merging for AVO and seismic inversion analysis East - Mexico. A case of study

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Summary

In the seismic processing stage, there has always been the uncertainty of the fact that seismic cube merge can be used for AVO and seismic inversion analysis. The seismic processing experts know that this type of projects mean a great challenge in the treatment that the seismic wavelet should have. That is to say, the analyst must be very careful because if it is used very drastic parameters in certain process this can mean eliminate or modify the response of the medium in the subsoil reflected in the amplitude, phase and frequency of the seismic traces.
Currently there are several methodologies to face the challenge of the seismic survey merging, and the following work shows the analysis carried out and applied in a project of the merge of five seismic surveys. In this work, two stages generated greater care, the first and the target of this study, as well as the calculation of the surface-consistent amplitude balancing in analyzed data, calculated by the root square mean technique, and based in the quadratic media value in statistics. In addition, the second stage of greater attention was the application of the interpolator in five dimensions.

The proposed methodology on this work is based on the analysis of seismic information, since the acquisition design and parameters like the grid, bin size, orientation, and previous source phase corrections, so the merging of the surveys can be standardized to a single reference. The workflow and the real correlation of the final processed seismic with the well data is shown in the seismic inversion results.

Theory / Method / Workflow

The surface consistent balancing analysis was made in three stages all of them on pre-stack seismic data. The first stage it is designed to analyze a gate of data from each input trace and compute an amplitude corresponding to each trace and write it into a local binary disk file.

The second stage reads the file(s) created by the first one and reduces the trace amplitude information to surface consistency in two passes. Bad traces, identified during the initial pass, are excluded from consideration during the second pass reduction. The surface-consistent scale factors for each model were written into the database as event attributes.

And the last stage read the attributes values for the desired models and applies the scale factors to the seismic data. One of the most important thing of this methodology is the ability to exclude anomalous traces from the solution phase makes this procedure more robust than conventional surface-consistent balancing methods that make no attempt to identify the traces that degrade the solution.

This methodology can be used as part of pre-stack processing whenever stratigraphic objectives are important. And like this case of study this approach to surface-consistent amplitude balancing is also appropriate for preparing data for AVO and seismic inversion analysis.

The methodology of this study was designed to calculate log absolute amplitude average, log this weighted absolute average amplitude or log RMS values for traces and tag each value with the header value (e.g., shot, rec_stat) from each of up to four analysis keys. In its strictest sense, surface-consistency is modeled in terms of the two components source location and receiver location. However, additional components, such as trace offset may be calculate to model additional physical or geometric effects.

The first stage computes the mean of either the absolute amplitude, weighted absolute amplitude or RMS amplitude within the time window of each input seismic trace and stores the logarithms of these values. Trace header values associated with each component specified (shot, rec station, offset and CDP) domain are stored with the amplitude values. These amplitude measures are subsequently reduced to surface-consistency by the second step to isolate the differences within the domains of the convolutional components. The amplitude balancing factors that are calculated and written into the seismic database are applied with the last stage of this methodology.
A related generalized surface-consistent model may be represented by the following equation (*Yilmaz, 1987*):

$$x_{ij}(t) = s_j(t) \times h_{i-j/2} \times e_{i+j/2}(t) \times q_i(t) + n(t)$$

where: $x_{ij}(t)$ = waveform of the trace with source location j and receiver location i
$s_j(t)$ = waveform component associated with the source location j
$q_i(t)$ = wave form component associated with receiver location i
$h_{i-j/2}(t)$ = component associated with the offset dependence of the waveform $(i – j)/2$

Also for this method the amplitude components may be represented in the Fourier domain by (*Cambois, 1992*):

$$A_x = A_s A_h Ae A_q$$

Solutions to the amplitude components in the above equation can be linearized by taking the logarithm of both sides.

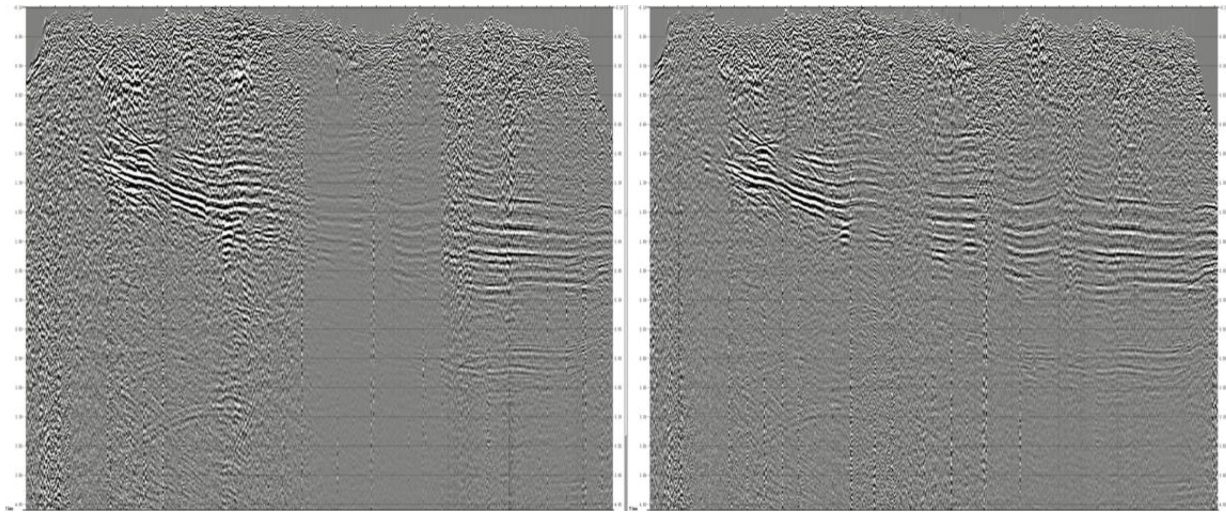
The log of the signal amplitude becomes the sum of the components (*Cary, 1993*).

$$In\ A_x = In\ A_s + In\ A_h + In\ A_e + In\ A_q$$

Finally, the components are subsequently determined by least-squares error minimization.

Results, Observations, Conclusions

The methodology was applied in East –Mexico reservoir. After the complete workflow applied, the results are show in line stacks (figure 1) and time slice (figure 2).



(a) (b)

Figure (1). Inline stack before the amplitude balancing (a). Inline stack after amplitude balancing (b).

In time slice is more evident the amplitude recover and balance (figure 2). The compensation of the weak traces has to be very accurate because if not the response of the AVO or the seismic inversion will be wrong.

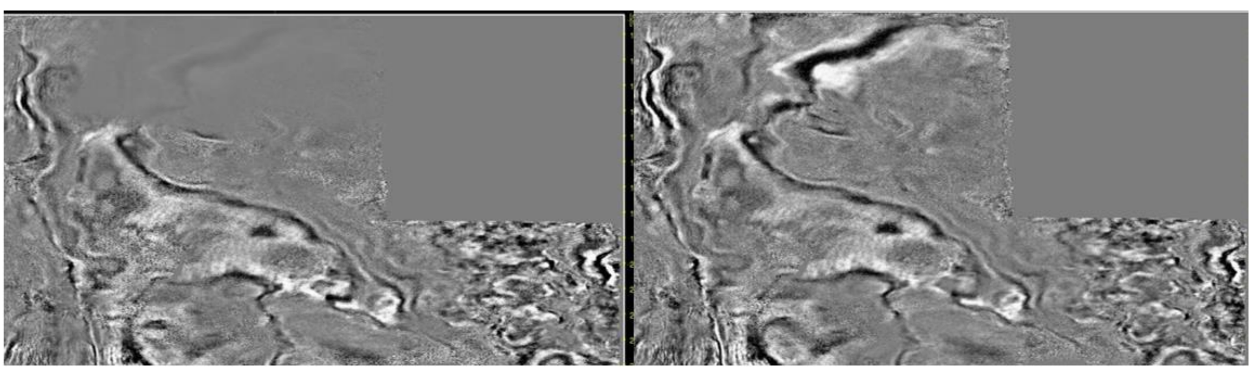
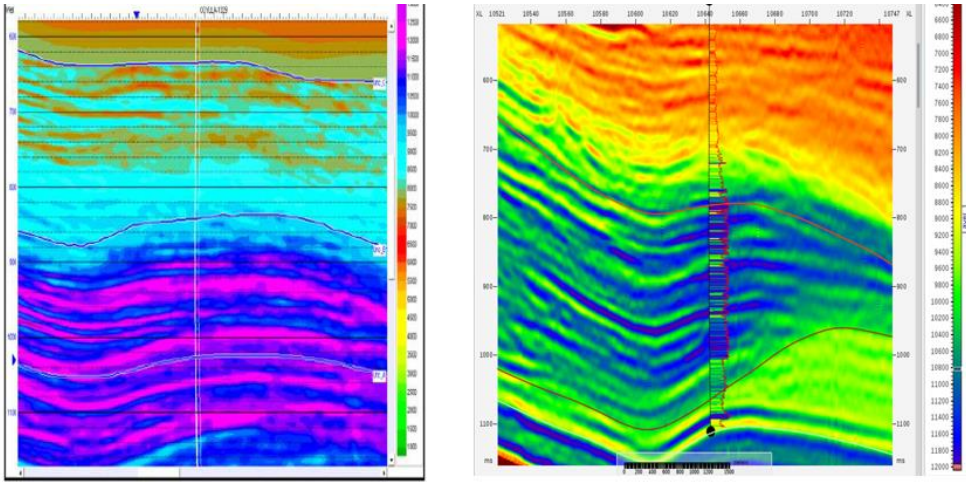


Figure (2). Time slice before the amplitude balancing (a). Time slice after amplitude balancing (b).

The final QC was implemented by seismic inversion. Figure 3 show the impedance P results of the Seismic Inversion compare to a previous study made in 2010 by Pemex – G & W Systems Corp – Stanford University in one of the target wells.



(a) (b)

Figure 3. Seismic Inversion – Impedance P result by Pemex – G & W Systems Corp – Stanford University (a). Seismic Inversion – Impedance P result Emerson-Paradigm Mexico.

Figure 4 show the final correlation of the seismic inversion impedance P and well log P impedance was 0.915 and is show in red line track number 6.

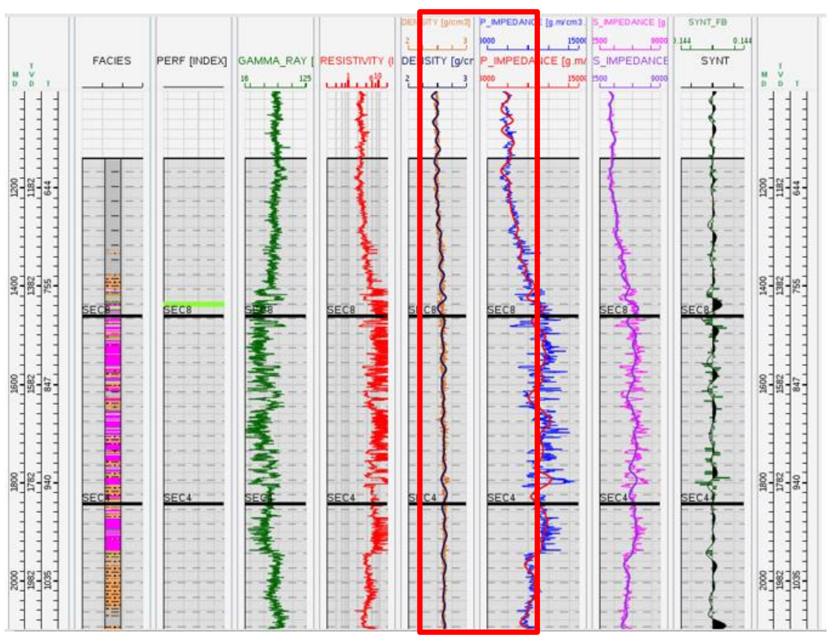
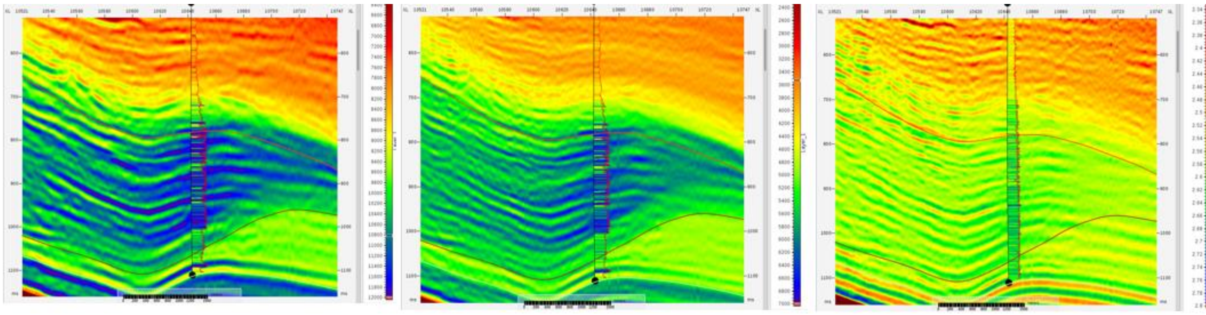


Figure 4. Seismic Inversion – Impedance P vs Well Log – Impendence P correlation 0.915

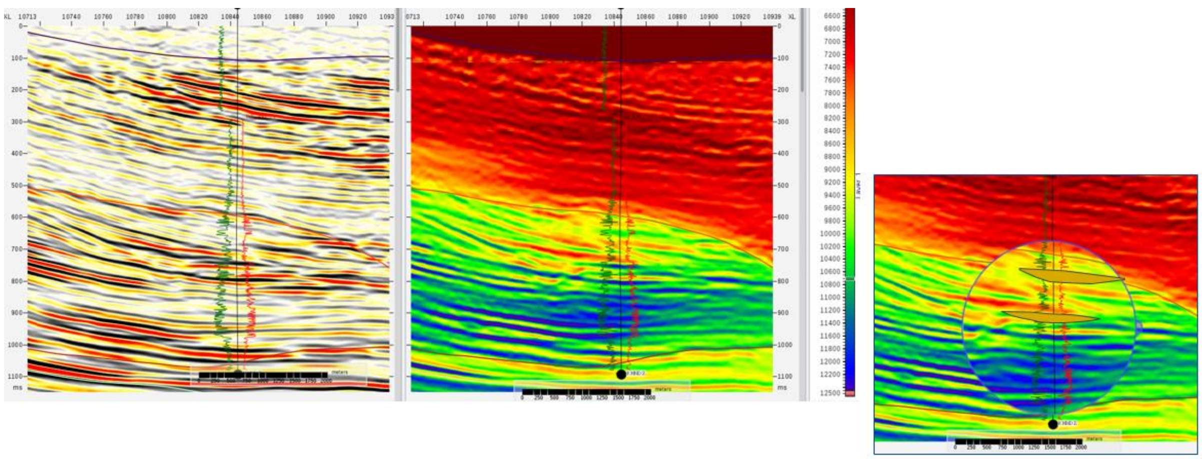
The figure 5 represent the impedance section result of the final seismic inversion at a strategic area, is evident the good impedance anomaly in the production interval.



(a) (b) (c)

Figure 5. Impedance P section at the control well. Impedance S section at the control well. Density section at the control well.

Figure 6 show the final result of the seismic inversion at one of the target areas and the production intervals were represented in a clear image by the seismic information.



(a) (b) (c)

Figure 6. Seismic section at the target interval (a). Impedance P section result at the target interval (b). Zoom Impedance P section result at the target interval (c).

The conclusion of this abstract is simple. We show the results of the surface consistent amplitude balance method in a case of study and the good correlation between the seismic information and the well information. In this case, we just want to balance the signal by the Square Root Arithmetical Mean. The results of the seismic inversion are very illustrate and the solution of the uncertainty in the target interval were solved by the surface consistent balance equation suggested.

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