Acoustic impedance inversion using stacking velocities: Hussar example

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Stacking Velocity Conditioning

FIG 1:Seismic and Well Ties from Hussar

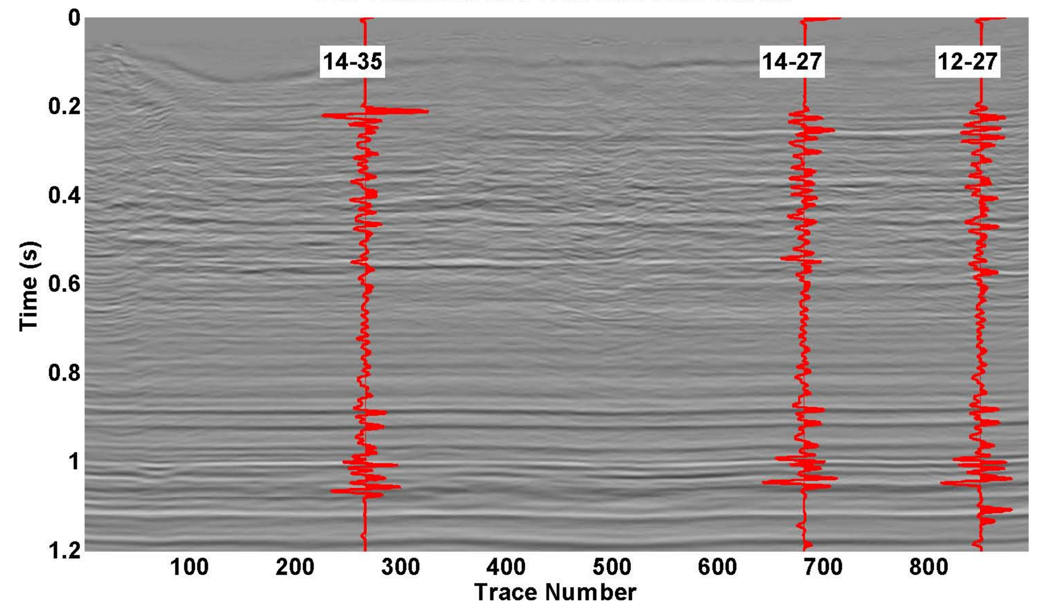


FIG 2: Picks for RMS Stacking Velocities

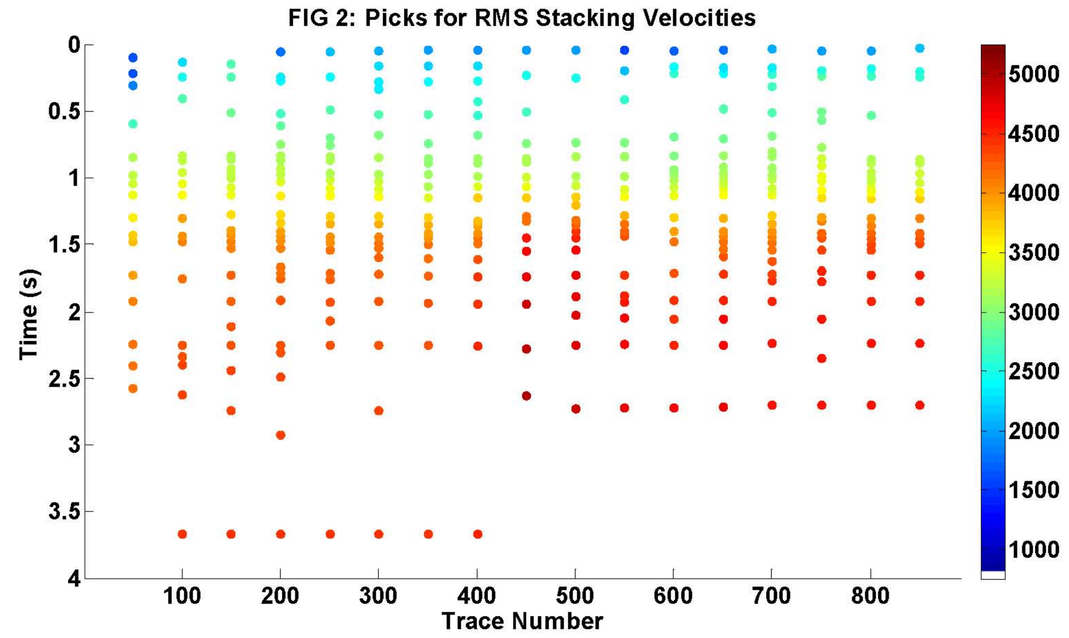


Figure 1 shows the migrated stacked seismic data from Hussar. During the processing of this data stacking velocities were picked as shown in Figure 2. It is possible to use the stacking velocities to calculate interval velocities which in turn can be used to calculate impedance.

FIG 3: Extrapolated RMS Stacking Velocities using PCHIP

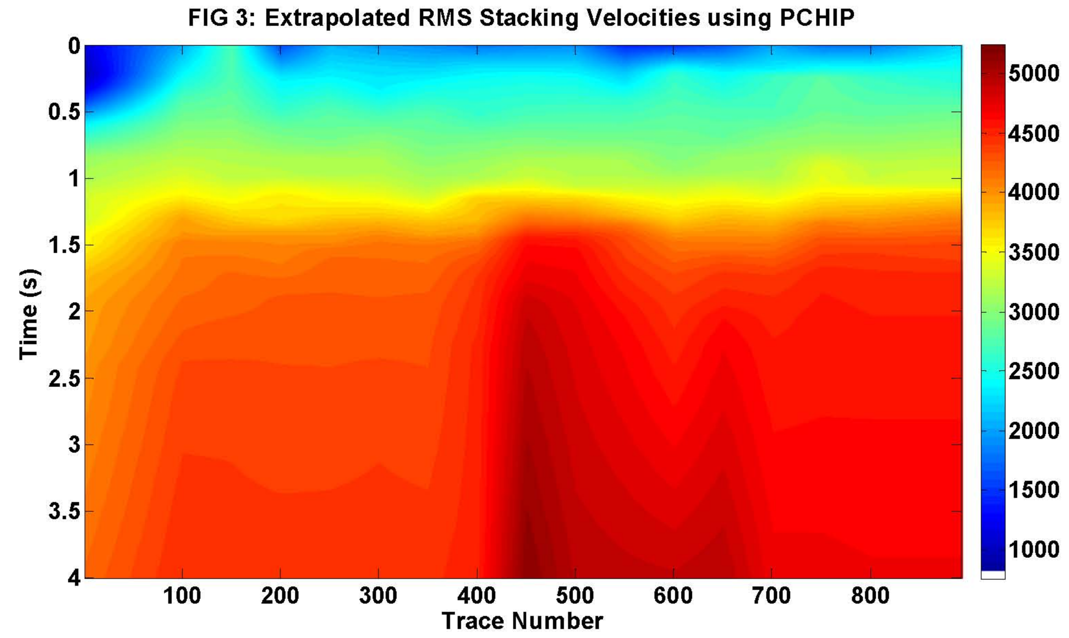
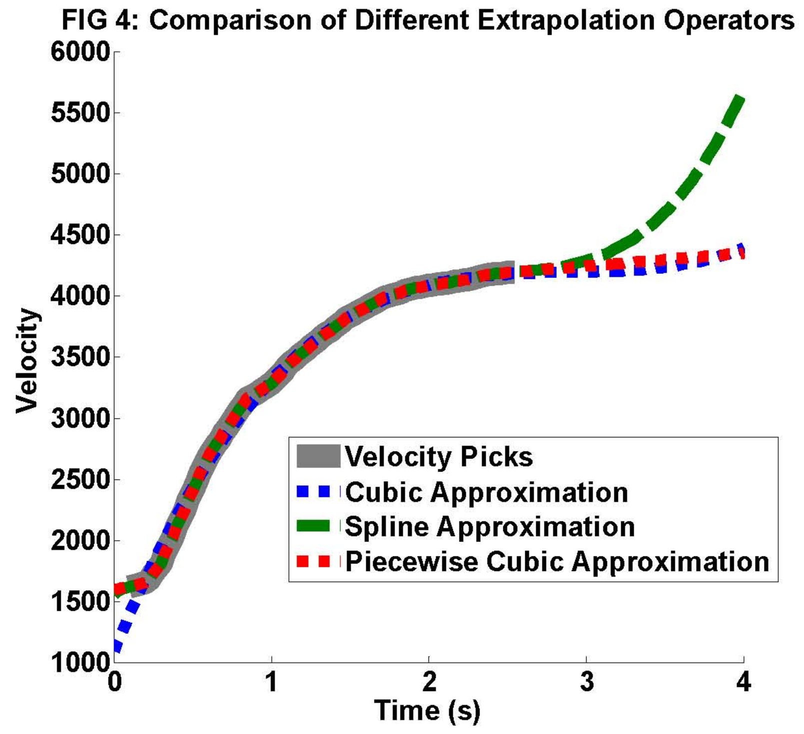


FIG 4: Comparison of Different Extrapolation Operators



These stacking velocities are very sparse so a smoothing operator needs to interpolate between the points, Figure 3. The PCHIP (Fritsch and Carlson, 1980) algorithm was used to do this as it best estimated the velocities where there were no point constraints, compared to other methods as shown in Figure 4.

Fritsch, F. N. and R. E. Carlson, 1980, Monotone piecewise cubic interpolation, SIAM J. Numerical Analysis, Vol. 17, 238-246.

Abstract

In bandlimited acoustic impedance inversion using the BLIMP algorithm, a low-frequency source is needed. This source is usually well logs but other sources such as stacking velocities can be used. Stacking velocities, are usually picked in a sparse way so they must be smoothed and interpolated to match the size of the seismic data. Once that is done, interval velocities can be calculated using RMS and interval velocity relationships. Impedance is created using the interval velocities and Gardner's equation to estimate the densities.

The resulting impedance section is missing too many high frequencies to use for rock properties so the BLIMP algorithm was used with a low-frequency cut-off of 2 Hz. Since there are large fluctuations in the impedance section it was smoothed by taking the average of all the traces and the inversion was repeated. The smoothed inversion had 11% error between 0.2 and 1.05 seconds where the regular inversion had and error of 12% in the same interval.

These results are not optimal so further smoothing techniques need to be investigated. Re-picking the stacking velocities by keeping this method in mind may also help to reduce the amount of error.

Interval Velocity and Impedance

FIG 5: Interval Velocities

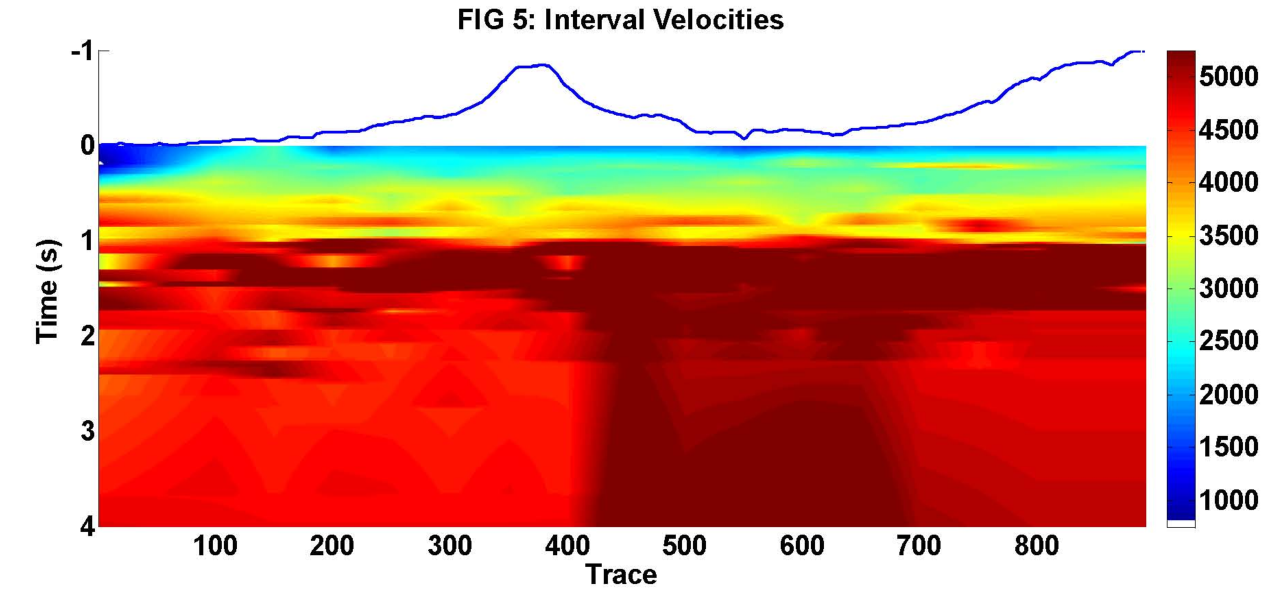
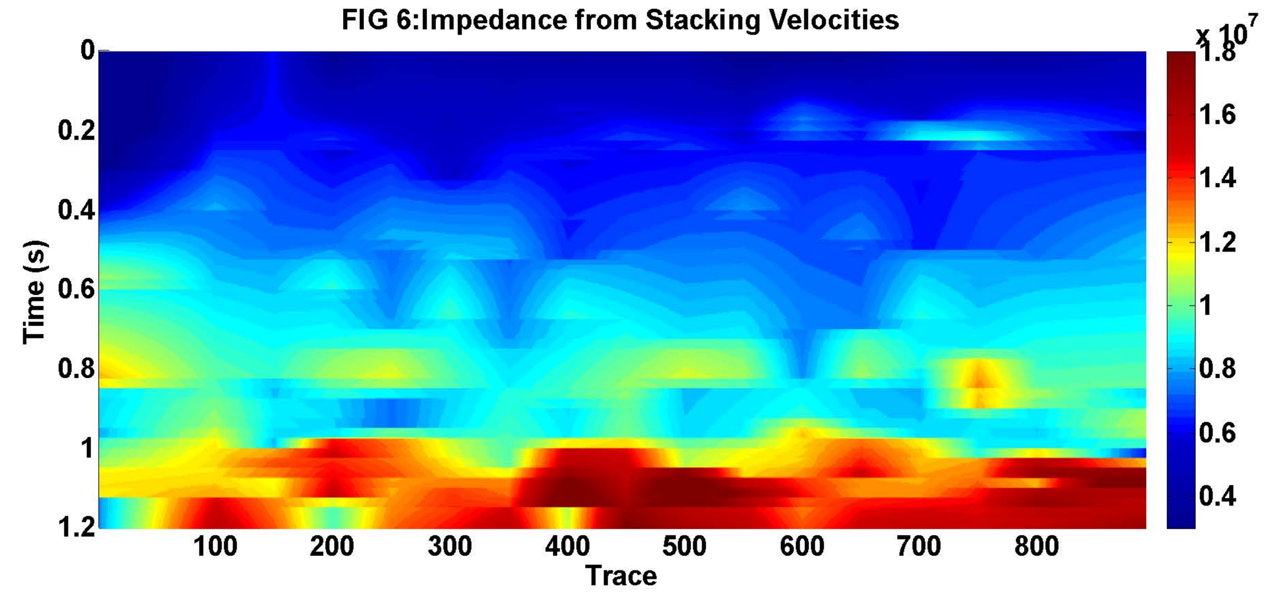


FIG 6:Impedance from Stacking Velocities



If we assume that the stacking velocities are close to the RMS velocities we can calculate the interval velocities, Figure 5. Densities can be approximated using Gardner's Equation and standard parameters (eg. Margrave, 2002). The Impedance section can then be calculated by multiplying the densities and interval velocities together, as seen in Figure 6. This impedance section is too low frequency to be used for property analysis but can become the low-frequency source for inversion.

Margrave, G. F., 2002, Methods of Seismic Data Processing Lecture Notes Geophysics 577: University of Calgary

Inversions

FIG 7: Impedance Inversion using Stacking Velocities

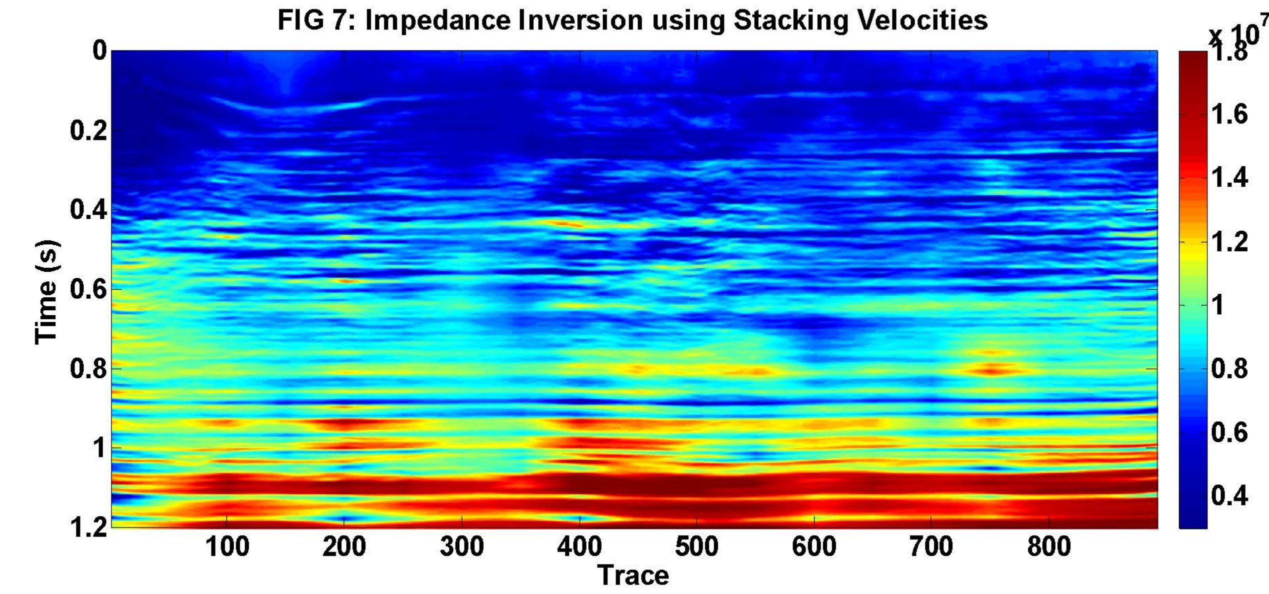
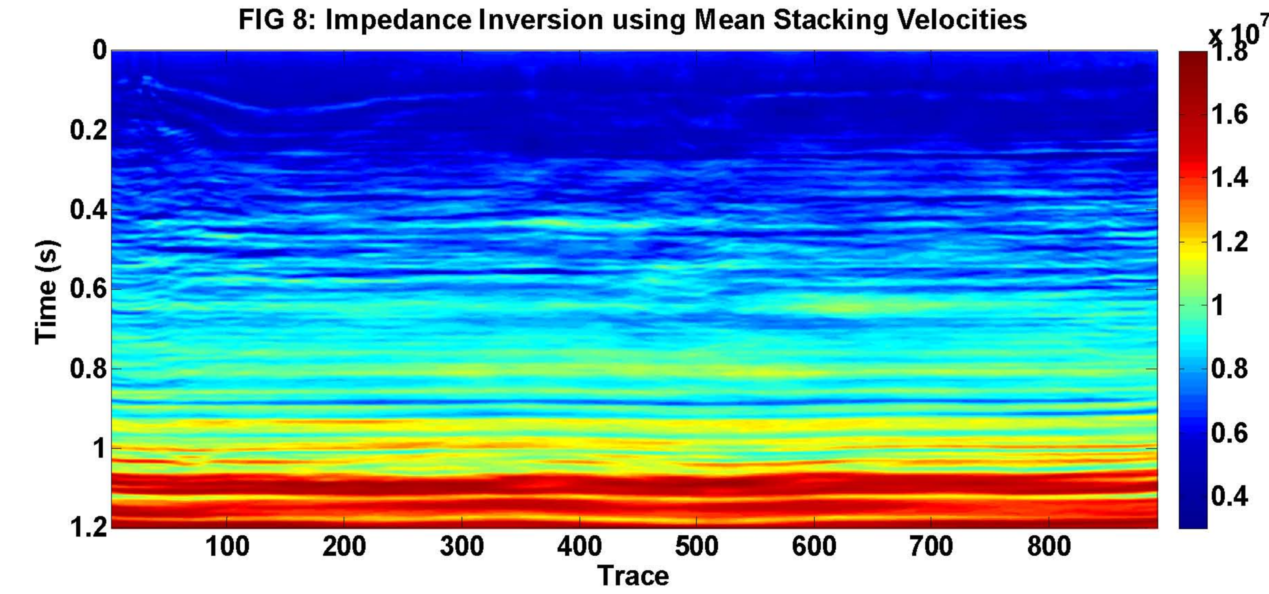


FIG 8: Impedance Inversion using Mean Stacking Velocities



The BLIMP algorithm (Ferguson and Margrave, 1996) was used with a low-frequency cut-off of 2 Hz to compute the inversion, Figure 7. This result is highly irregular. Since it is common to smooth interval velocities due to small errors in the stacking velocities causing large errors in the interval velocities, the inversion was repeated using an average of the interval velocities, Figure 8.

FIG 9: Stacking Velocity Cross-Validation

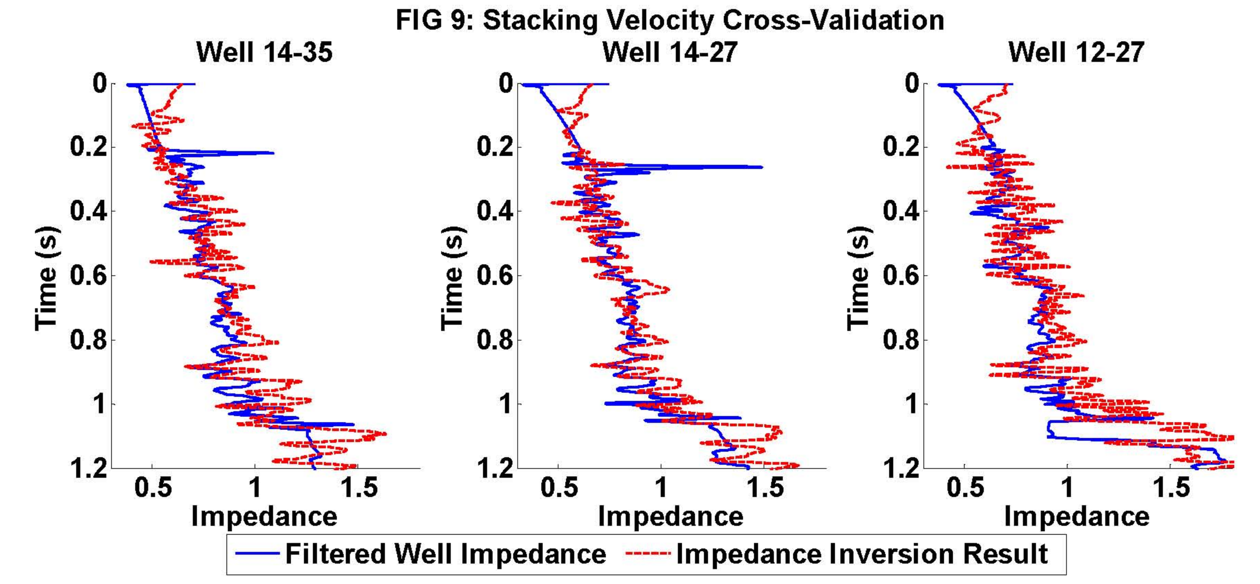
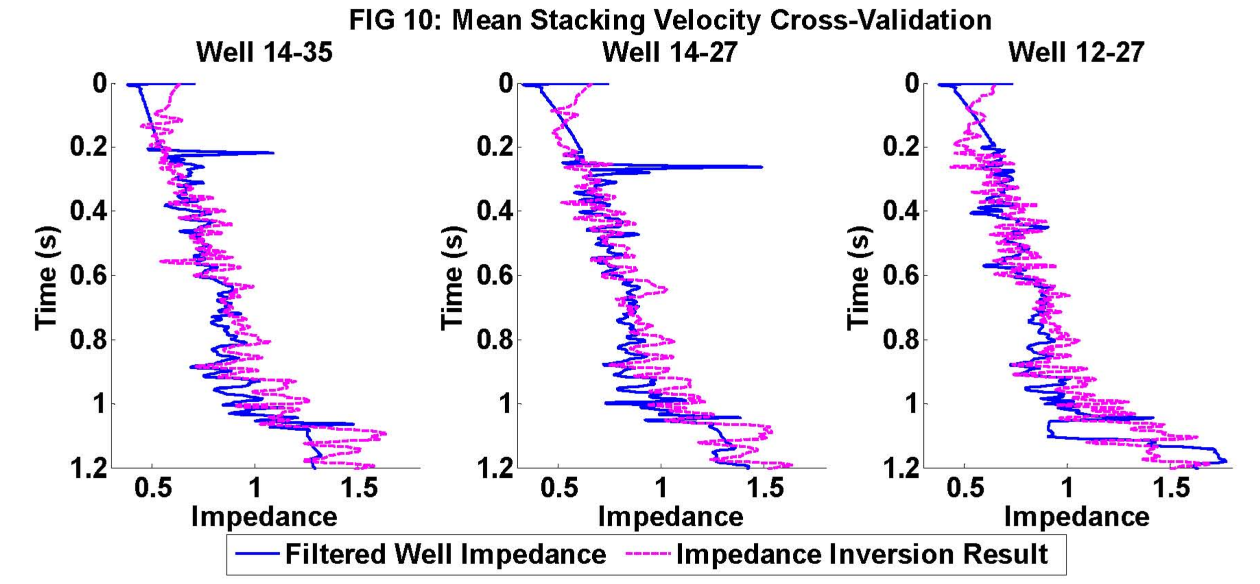


FIG 10: Mean Stacking Velocity Cross-Validation



Cross-validation tests were used to determine the accuracy of the impedance inversion (Figure 9,)and the smoothed impedance inversion (Figure 10). The smoothed result is 1 % more accurate in the interval between 0.2 and 1.05 seconds.

Ferguson, R. J. and Margrave, G. F., 1996, A simple algorithm for bandlimited impedance inversion: CREWES Research Report, Vol. 8, No. 21.