Residual converted wave statics

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ABSTRACT

First estimates of S-wave receiver static shifts are applied to selected common receiver gathers of the Spring Coulee three component survey. Pre-processing of the input common receiver gathers includes NMO-correction, deconvolution, P-wave shot statics application, AGC and a band-pass filter. Residual S-wave receiver static shifts are computed from shot records obtained by resorting the chosen subset of receiver gathers. Prior to this computation of residuals the shot records are preconditioned by estimating and removing *DC-bias* as well as *residual normal move-out*. When stacking *residual-receiver-static* corrected shot records, little difference is found on comparing to shot stacks without residual application. Further analysis by velocity-sweep trial-stacks and residual normal move-out removal reveals *non-hyperbolic move-out* as a possible cause for the observed stacking response.

INTRODUCTION

The computation of *first-estimate* (initial) converted wave receiver static corrections from common receiver stacks is described in a previous report by the authors (Haase and Henley, 2008). There, a cross-correlation / outlier-rejection method is applied to selected common receiver gathers of the Spring Coulee three component survey. As a continuation of our 2008 study we apply the derived *first-estimate* receiver static corrections to all traces of the selected data subset and then proceed by analyzing shot records (as opposed to common receiver gathers in previous work). The first step is to estimate and remove any DC-bias as well as any residual normal move out (RNMO) from these shot records. Secondly, we compute residual receiver static corrections from cross-correlation lags of nearby traces (this is the same procedure as applied to common receiver gathers in previous work). These *residual* receiver static shifts are then applied to shot records corrected with *first-estimate* receiver shifts. When stacking shot records thus corrected, little difference is found on comparison with stacked shots with only *first-estimate* receiver corrections applied. As a next step we investigate this unexpected result by analyzing velocity-sweep trial-stacks and an individual shot record.

DC-BIAS AND RNMO REMOVAL

From the 20 *first-estimate* corrected common receiver point gathers selected for this investigation (with 192 traces each) we obtain 192 common shot records (CSR) with 20 traces each. Cross-correlation time shifts of the 5^{th} and 97^{th} CSR before and after DC-bias / residual-NMO correction are displayed in Figures 1a and 1b; also plotted are the model-curves (according to Equation 2 of Haase and Henley, 2008) fitted to the time shifts before these corrections. As can be seen in Figures 1, there are non-zero DC-bias / residual-NMO estimates that show offset dependence. The one-sided offset distribution of Figure 1b is caused by data subset selection and the resulting fold restriction.

RESIDUAL RECEIVER STATICS COMPUTATION AND APPLICATION

Residual source point static shifts are the same for every trace of a given shot record (CSR). Cross-correlations within a CSR ignore this common source shift, but they are sensitive to the difference in residual receiver static shifts between traces that are input to the correlation. Every cross-correlation involves two receivers, and an over-determined system of equations is set up to solve for the individual receiver static contributions in the least-square-error sense. The result of this computation is plotted in Figure 2 together with the *first-estimate* receiver statics. From Figure 2 we see that residual receiver static is indeed smaller than *the first-estimate*.

Stacking the traces within each first-receiver-static-estimate corrected shot record gives the CSR-stack traces in Figure 3. When also applying residual receiver statics to all traces (before stack) we obtain the CSR-stack of Figure 4. The red traces in Figures 3 and 4 are the stacks of CSR number 72. Figure 5 shows the difference between trace 72 of Figure 3 and trace 72 of Figure 4. Apparently our residual receiver statics correction made little difference to the CSR-stack. Figure 6 displays the equivalent CSR-trace difference for trace 72 before stack. As can be expected the difference is small for small static shifts but this result is just as inconclusive.

The traces of CSR 72 without the above receiver static corrections are plotted in Figure 7. The dominant reflection at approximately 760 ms is flat because of correctly picked stacking velocities. When applying both, initial and residual receiver static corrections to CSR 72 (Figure 7) we obtain the traces seen in Figure 8 and we observe residual move-out (RNMO). RNMO removal from the original CSR 72 results in the trial stacks of Figure 9. The green trace at the center of Figure 9 represents maximum stacking amplitude; at the center the original stacking velocity is applied and away from the center it is increased / decreased. For the original data the original stacking velocity is therefore optimal. A different picture emerges in Figure 10: Trial stacks of static corrected CSR 72 (both, initial and residual receiver static) show a shift of the maximum stack amplitude trace (in red) away from the center of the display thereby indicating non-zero RNMO. Figure 11 is the result of RNMO removal from static corrected CSR 72. There is clear evidence of non-hyperbolic move-out in Figure 11. This is not too surprising because converted waves follow non-hyperbolic move-out patterns. For further improvement of the stacking response this non-hyperbolic move-out must be accounted for.

CONCLUSIONS

Following S-wave receiver static correction with a *first-estimate*, *residual* receiver statics are computed from selected shot records of the Spring Coulee three component survey. Similar to the *first-estimate* procedure we remove any DC-bias (structure term) and any residual normal move-out from cross-correlation lags of traces within each shot record first. Individual receiver static contributions are found from the least-square-error solution of an over-determined system of equations set up with these conditioned cross-correlation lags. When applying first-estimate and residual receiver static corrections we observe residual NMO in shot records. Hyperbolic RNMO removal does not flatten the dominant reflection event which proves that a non-hyperbolic approach is required here.

The next step in this project is to use CDP-gathers as input data and estimate residual shot statics as well as residual receiver statics simultaneously taking into account the non-hyperbolic nature of the problem.

ACKNOWLEDGEMENTS

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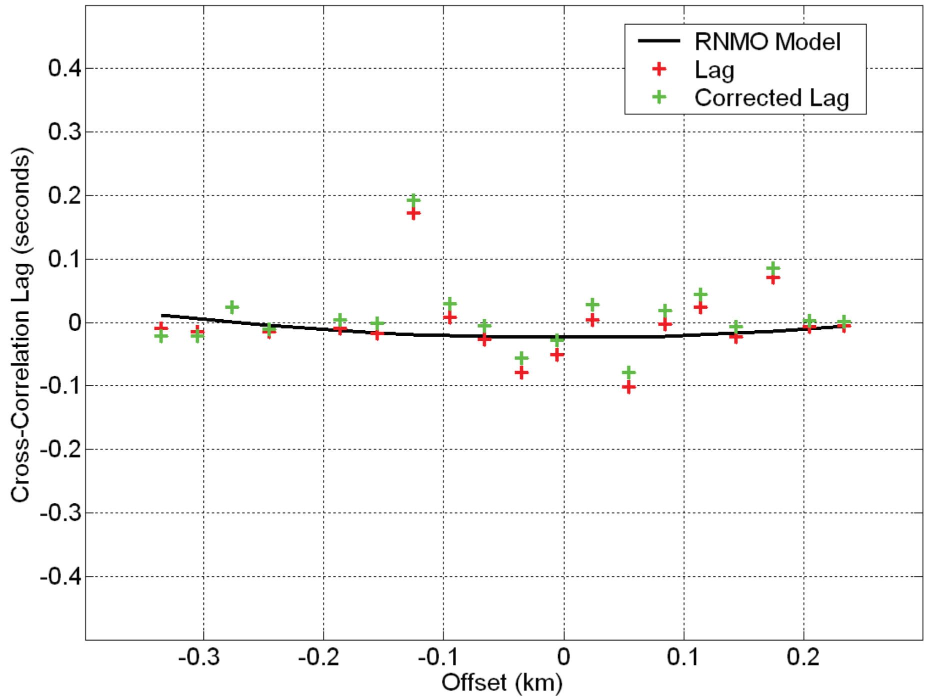
REFERENCES

Haase, A.B., and Henley, D.C., 2008, Residual converted wave statics: CREWES Research Report, Volume 20



.FIG. 1a. Spring Coulee DC-bias and residual-NMO estimate for Shot Record 5.

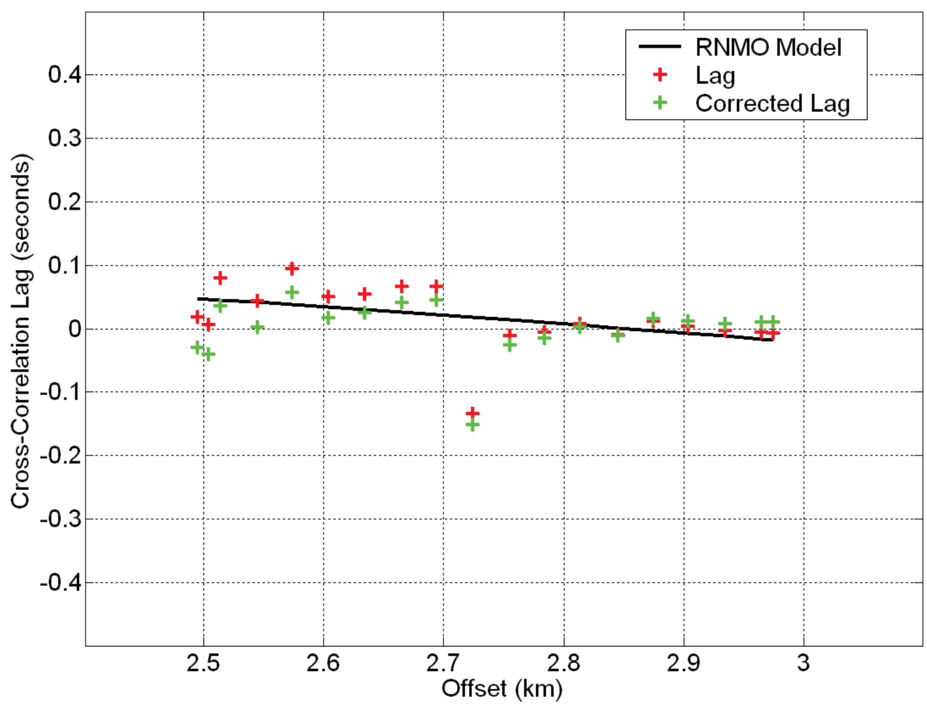


FIG. 1b. Spring Coulee DC-bias and residual-NMO estimate for Shot Record 97.

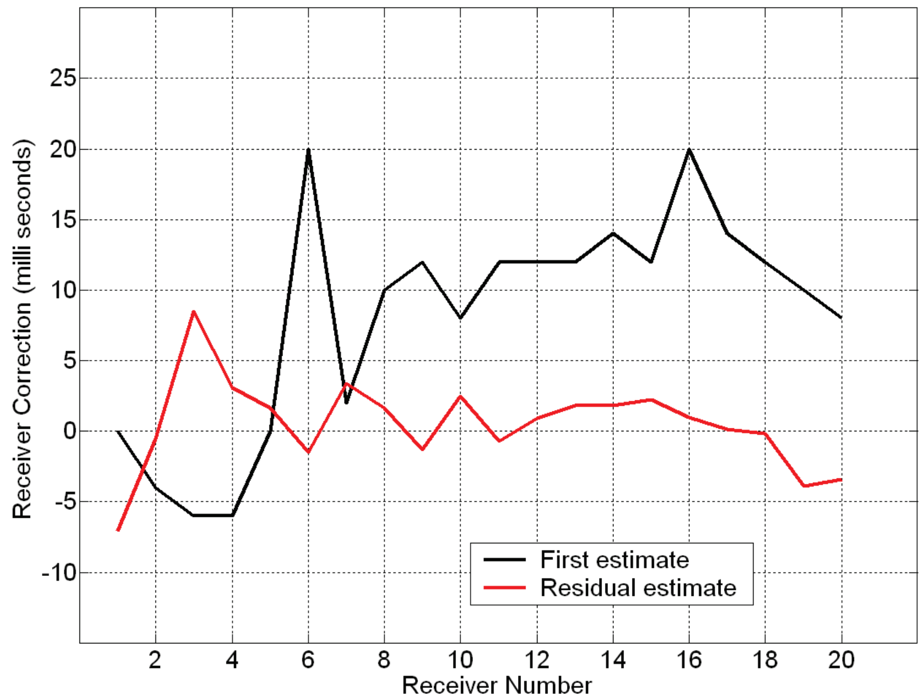


FIG. 2. Spring Coulee receiver static correction.

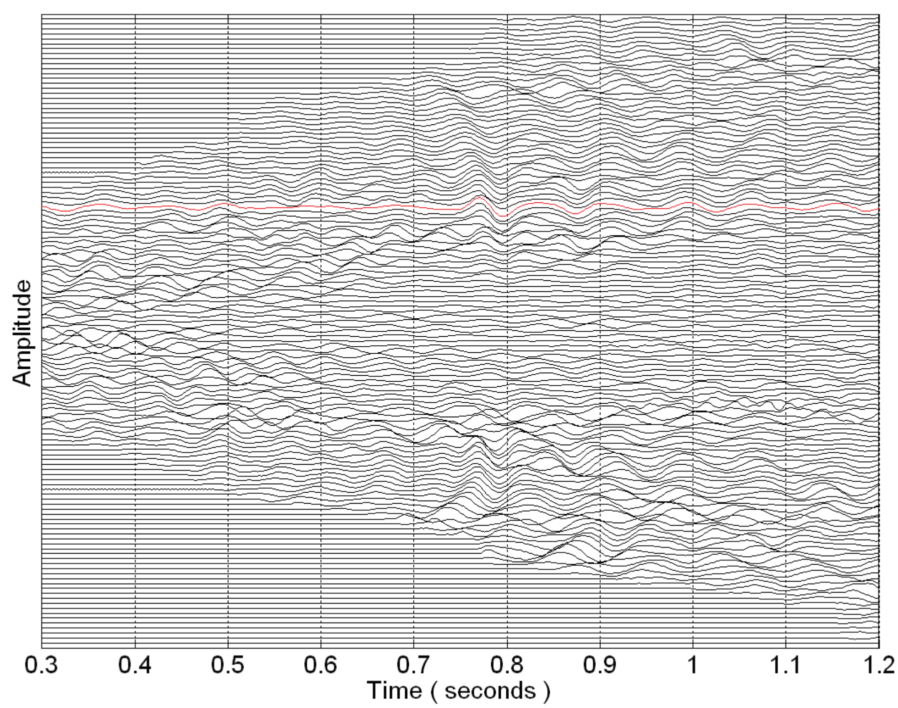


FIG. 3. Spring Coulee Shot Record stack (first-estimate receiver static only).

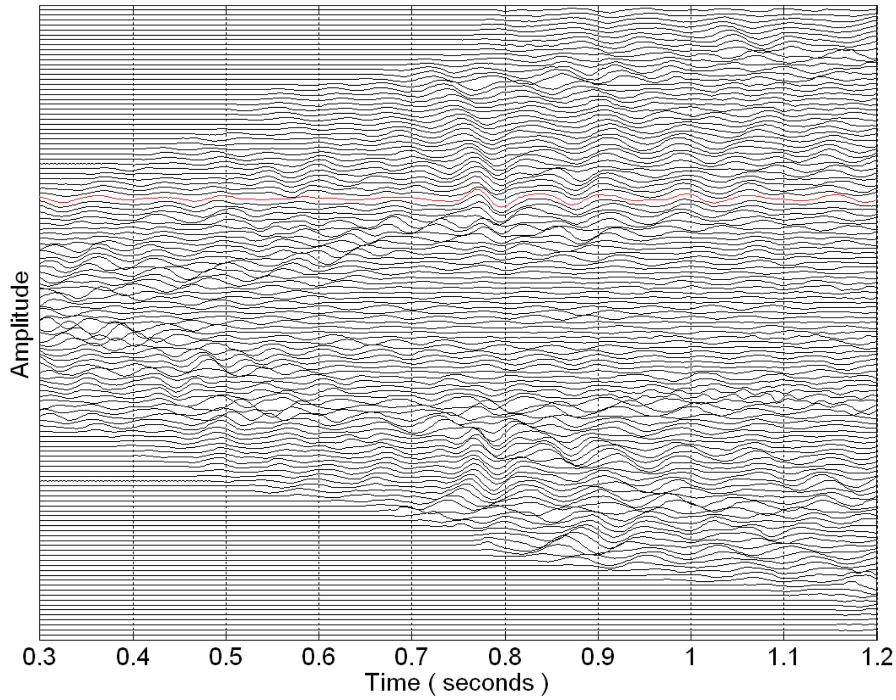


FIG. 4. Spring Coulee Shot Record stack (initial and residual receiver static).

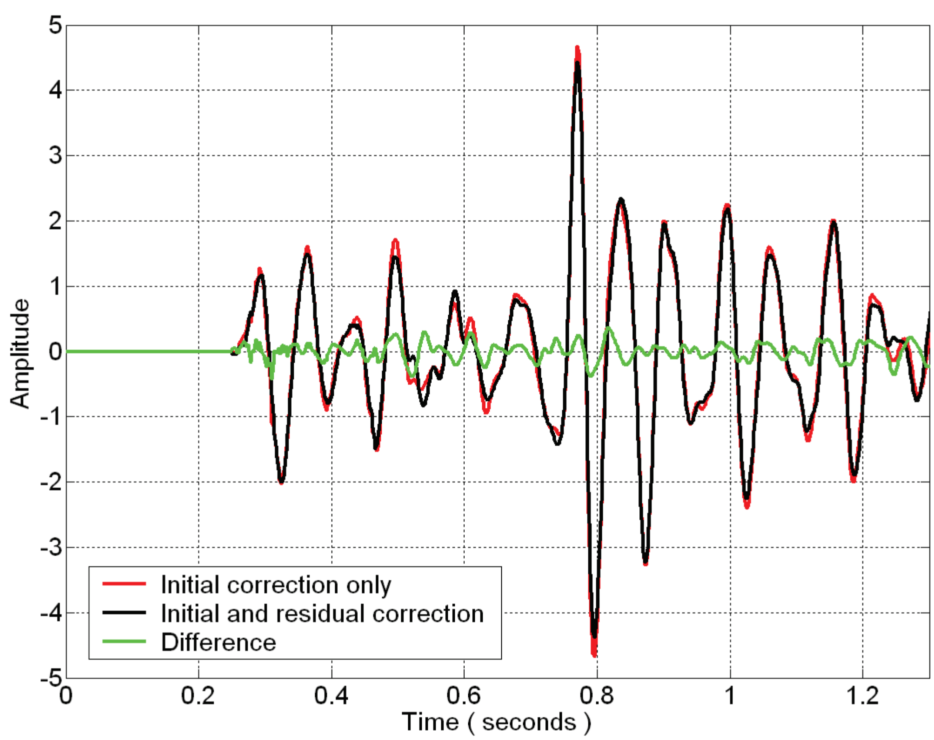


FIG. 5. Shot Record stack trace 72 (receiver static correction applied).

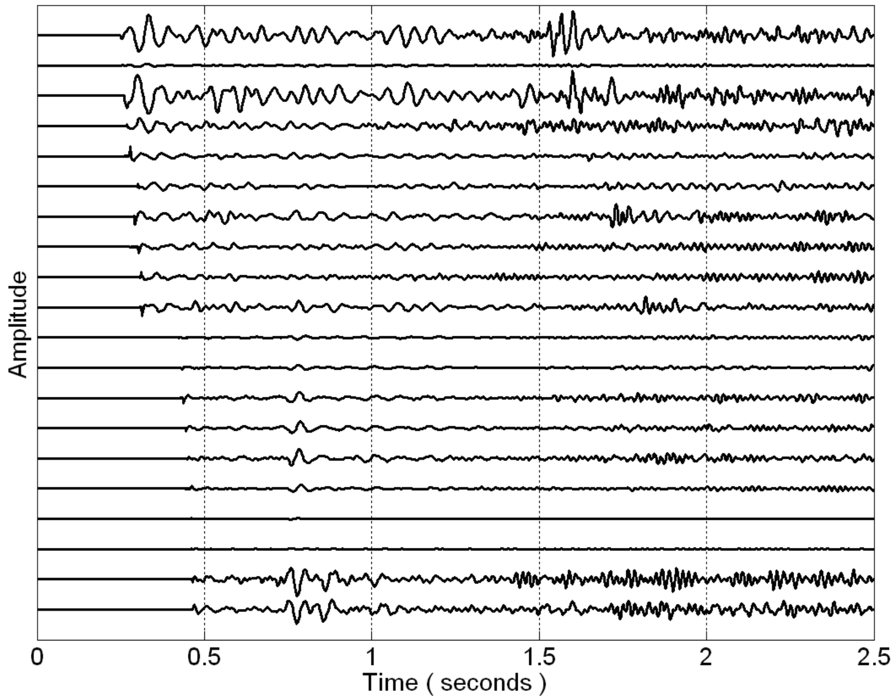


FIG. 6. Shot Record 72 difference (initial+residual minus initial receiver statics only).

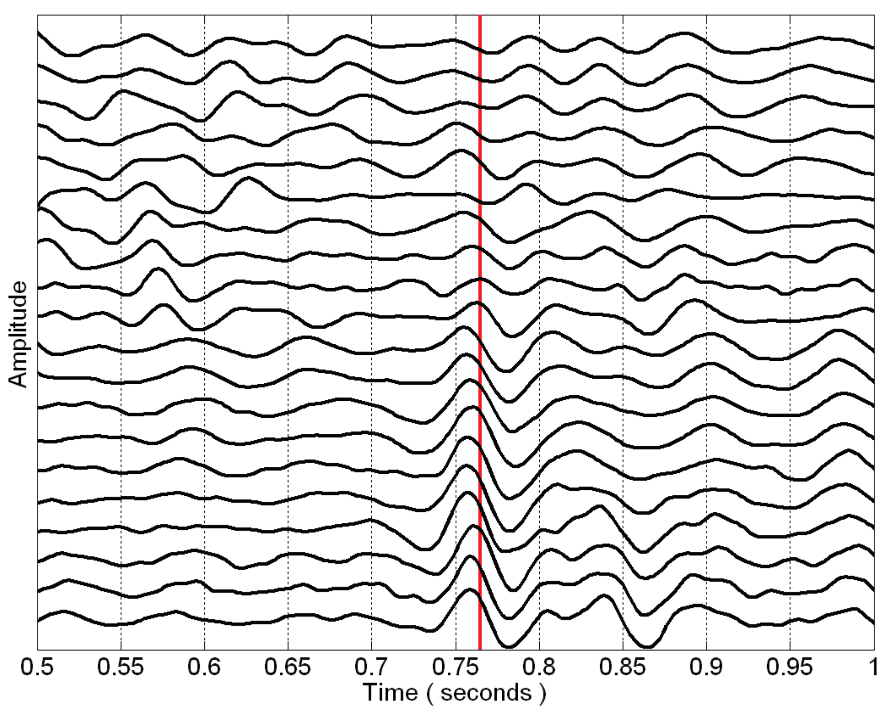


FIG. 7. Shot Record 72 without corrections (neither statics nor RNMO).

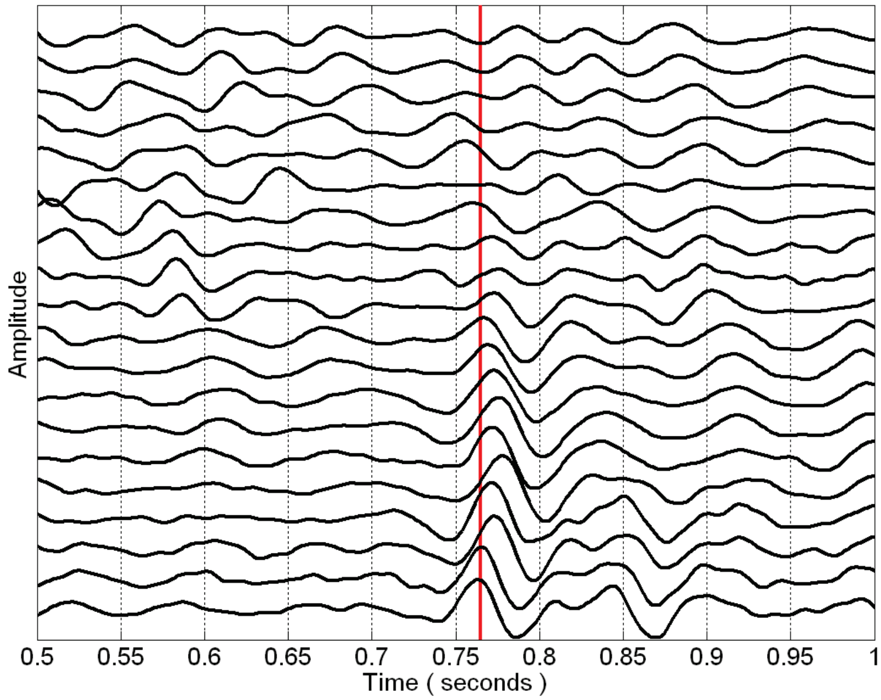


FIG. 8. Shot Record 72 with initial and residual receiver static corrections.

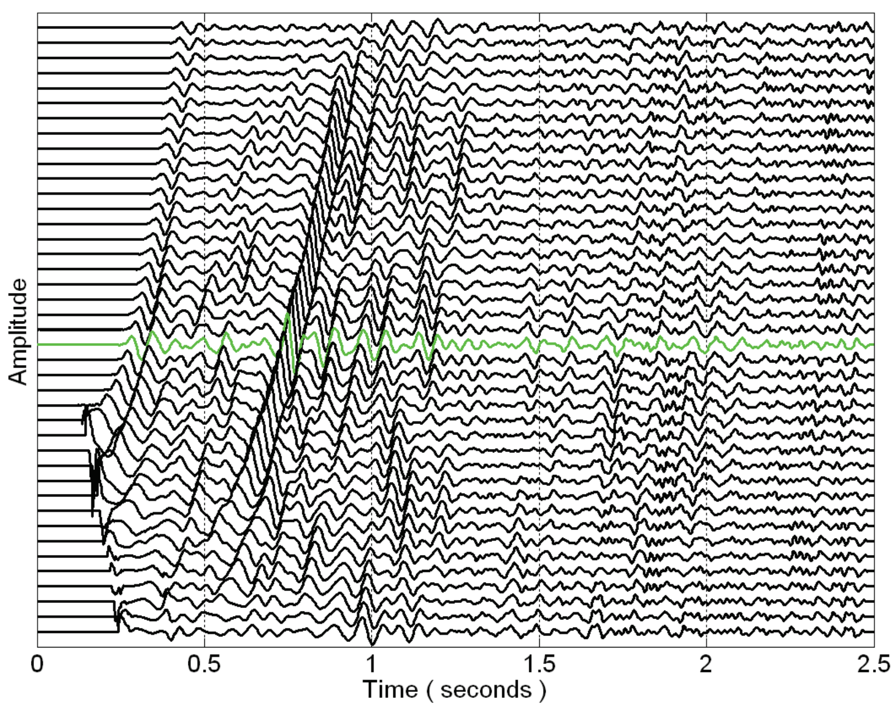


FIG. 9. Velocity-sweep trial-stacks of the original Shot Record 72. The green trace indicates maximum stack amplitude.

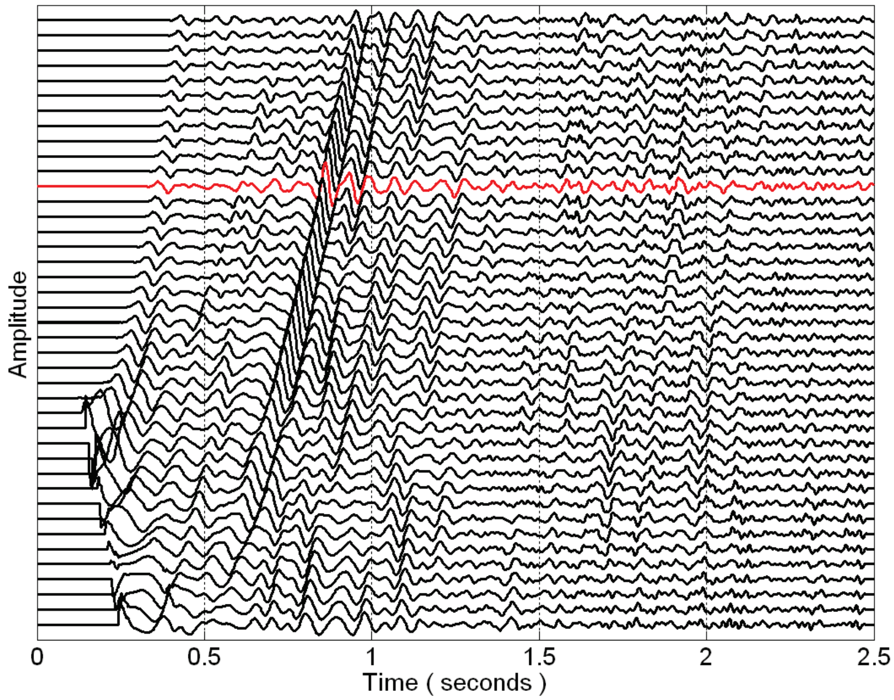


FIG. 10. Velocity-sweep trial-stacks of the static corrected Shot Record 72. The red trace indicates maximum stack amplitude.

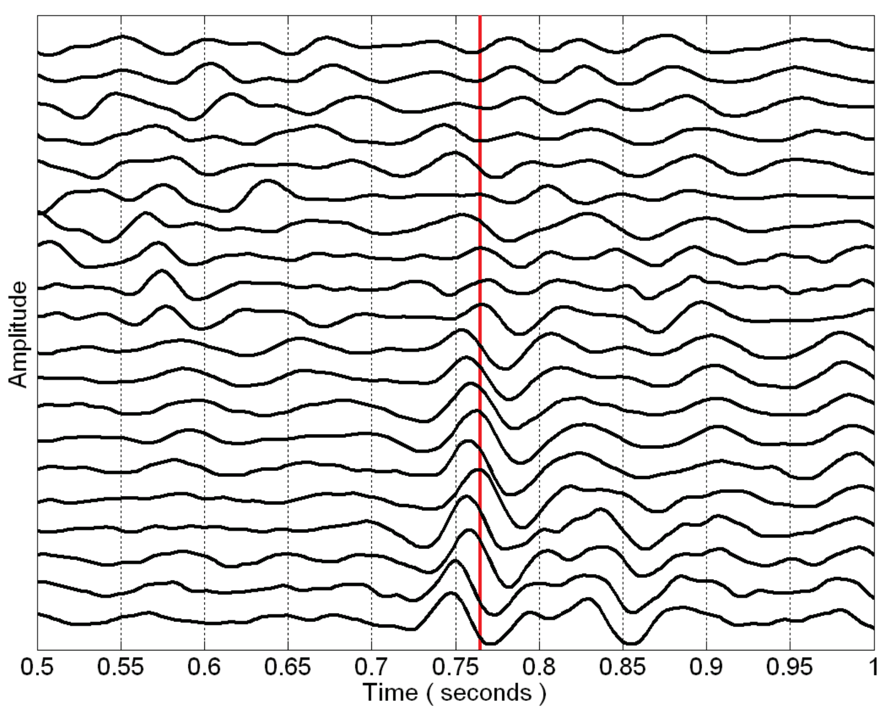


FIG. 11. Shot Record 72 with static corrections, hyperbolic RNMO is removed.