The effect of receiver statics on CCP stacks: An example from Spring Coulee, Alberta

J. Helen Isaac and Gary F. Margrave

helen.isaac@ucalgary.ca

ABSTRACT

A common method of estimating receiver statics for PS data is to pick a horizon on stacked receiver gathers and calculate the statics necessary to either flatten the horizon or smooth it. We investigated the effects of different smoothing operator lengths and the results of using two horizons rather than just one. There were surprising differences in coherency and continuity of reflectors on the final CCP radial component stacks caused by the use of different smoothing operator lengths. The number of points in the smoothing operator that gave the best continuity also varied across the line. We chose the final smoothing operator length to be that which gave the best overall continuity of reflectors.

The method probably works best in areas of no structure, where flattening an event on receiver stacks does not harm true structure. In areas with a small amount of geologic structure, the amount of smoothing of the horizon picked on receiver stacks should be studied carefully before final receiver statics are selected. This method is not appropriate for areas with significant structure.

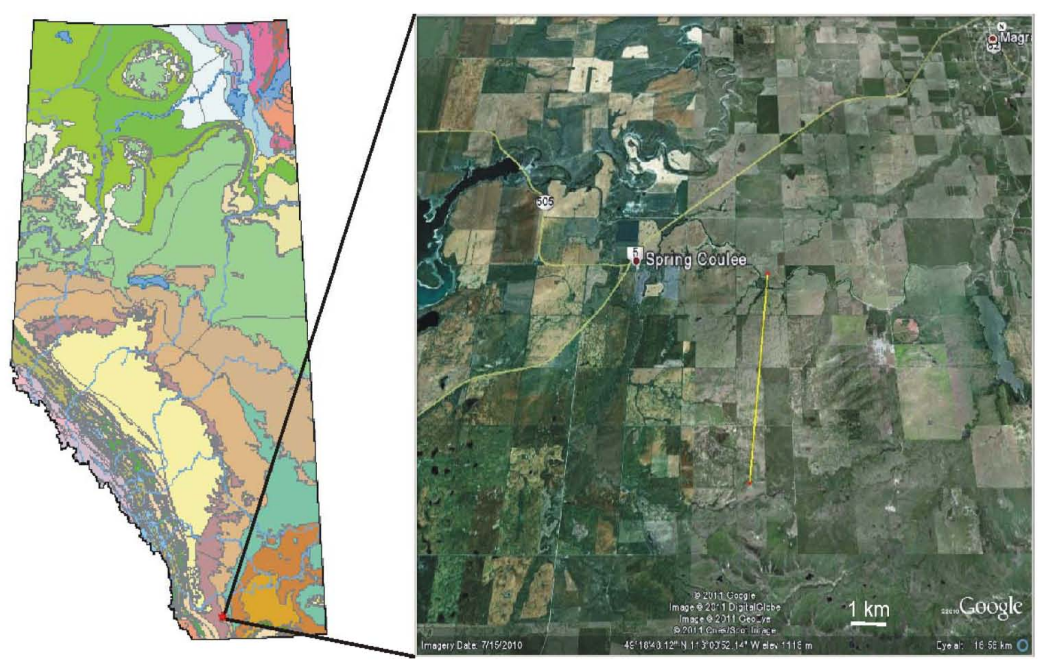

FIG. 1. The study area at Spring Coulee, Alberta.

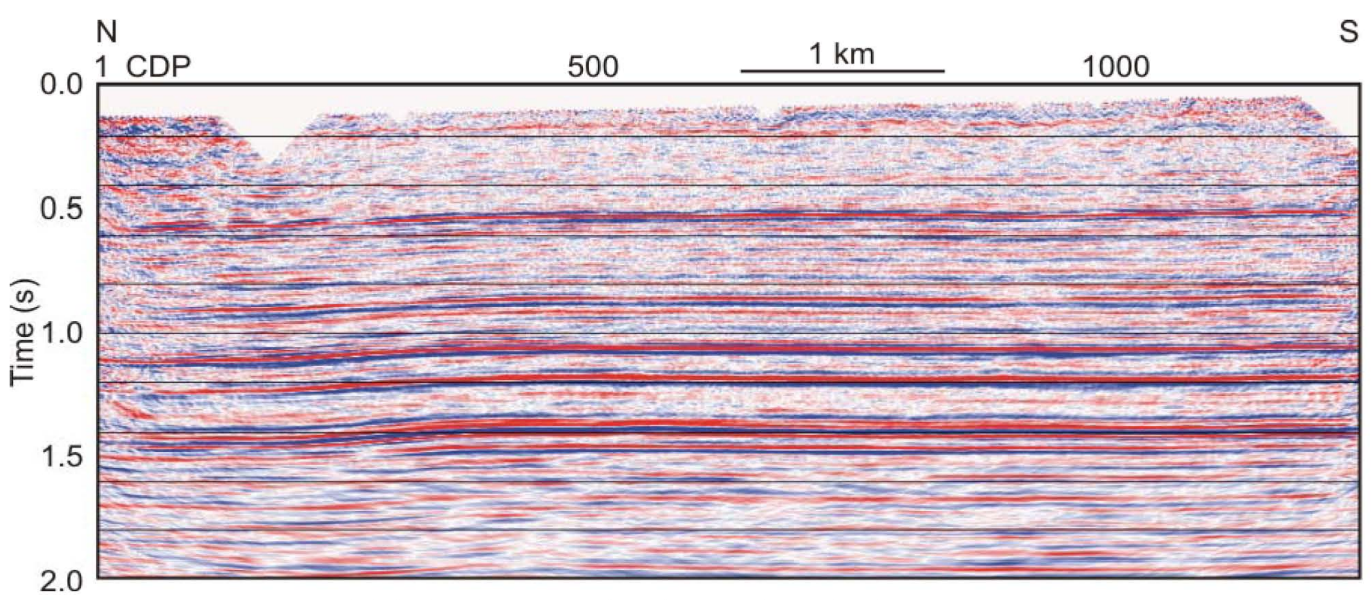

FIG. 2. Post-stack migrated vertical component.

METHOD

We processed 3C data acquired at Spring Coulee in Southern Alberta (Figure 1) in 2008. There were 192 vibroseis sources at 30 m station intervals and the 10 Hz 3C geophones were at 10 m station intervals. We first processed the vertical component to obtain the shot static solution and to observe the structure of the subsurface. Processing included surface noise wave attenuation, phase-amplitude Q-compensation and Gabor deconvolution. The post-stack time migrated section of the vertical component is shown in Figure 2.

Similar processing was applied to the radial component of the 3C data. To estimate the receiver statics we created stacks of receiver gathers on which to pick one or more horizons. We used a simple single velocity function based upon NMO observed on reflectors in the receiver gathers and applied elevation statics to the final datum to avoid introducing false structure by using the floating datum. The receiver stack with two horizons we picked is shown in Figure 3. There is clearly a tough receiver statics problem to be solved. We investigated the results on the stacked CCP section of picking either one horizon or two horizons and averaging the results, and of different smoothing filters.

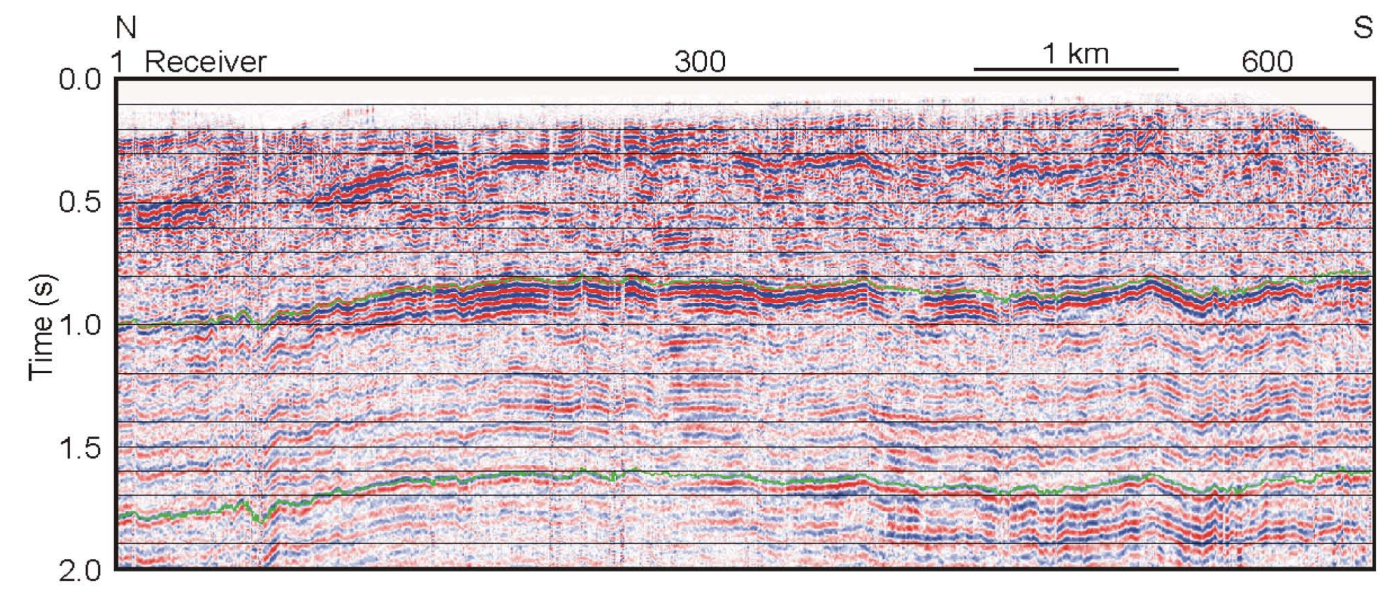

FIG. 3. The stacked receiver gathers. There is clearly a tough receiver statics problem to be resolved. The green lines are two horizons we picked.

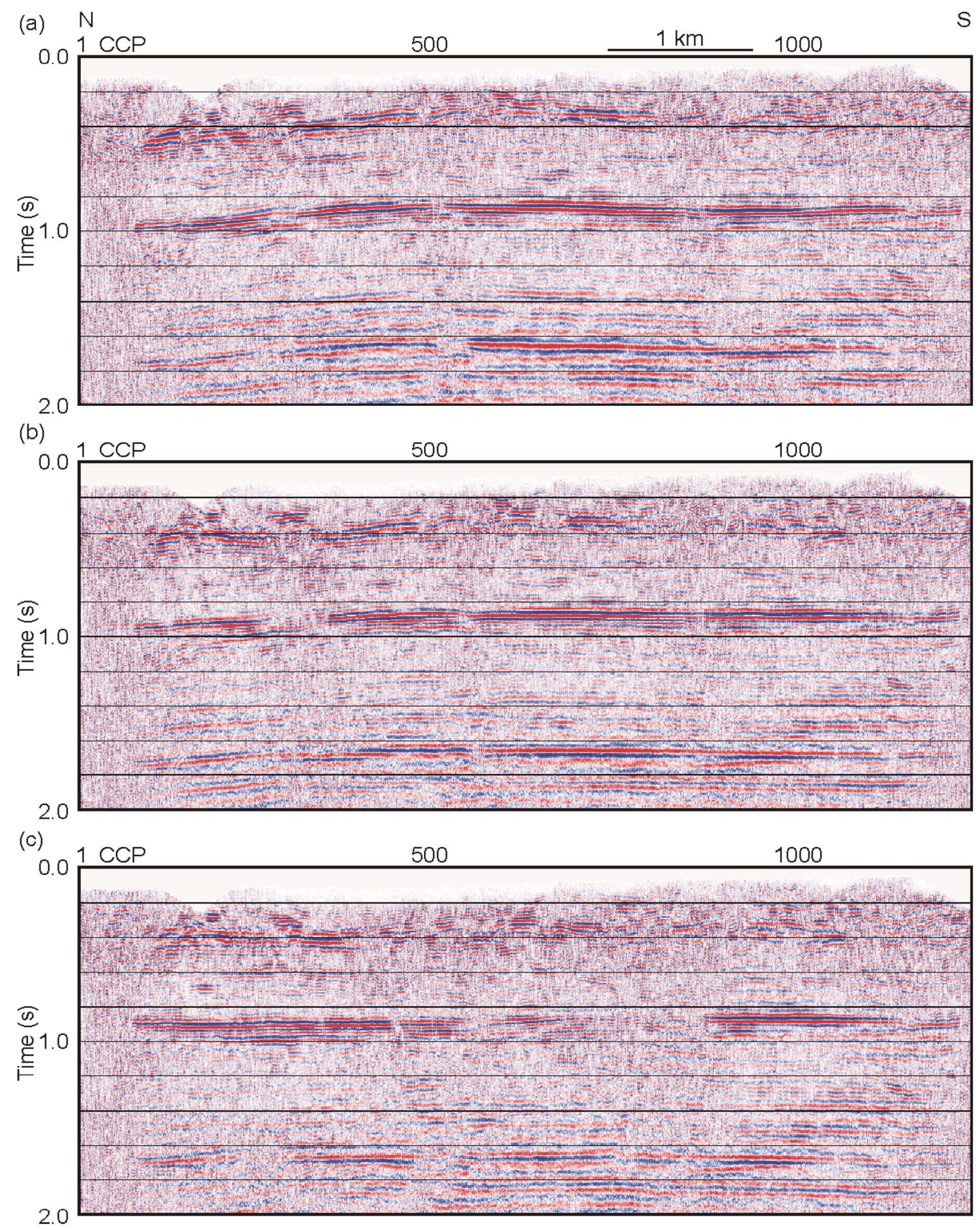

FIG. 4. Three receiver stacks with different statics calculated from the difference between the shallow picked horizon and a smoothed version of that horizon. The smoothing operator lengths were (a) 201, (b) 301 and (c) 401.

The PS data were binned into CCP gathers using Vp/Vs of 2.01 and the data stacked with different receiver statics applied. These statics were obtained by calculating the difference between the shallower horizon picks near 0.9 s in Figure 3 and those picks smoothed with different lengths of smoother operator. Figure 4 shows three CCP stacks which had smoother lengths of (a) 201, (b) 301 and (c) 401 receiver stations. It is quite surprising how much difference the smoother length makes. A smoother length of 301 gives the best result over CCPs 500 to 1000 and a length of 401 gives the better result over CCPs 1 to 500. However, with a length of 401 we lose coherency between 500 and 1000. In Figure 5 we smoothed the shallow horizon with a length of 501 (a) and with the picked event flattened completely (b). Clearly, different smoother lengths work best on different parts of the line. Thus we compromised by using a smoother length of 331 on both horizons and averaging the two statics estimations (Figure 6). This is probably the best CCP stacked radial component section. Vertical and radial migrated sections are presented in Figure 7, scaled so that corresponding reflectors line up. The polarity of the radial section was reversed.

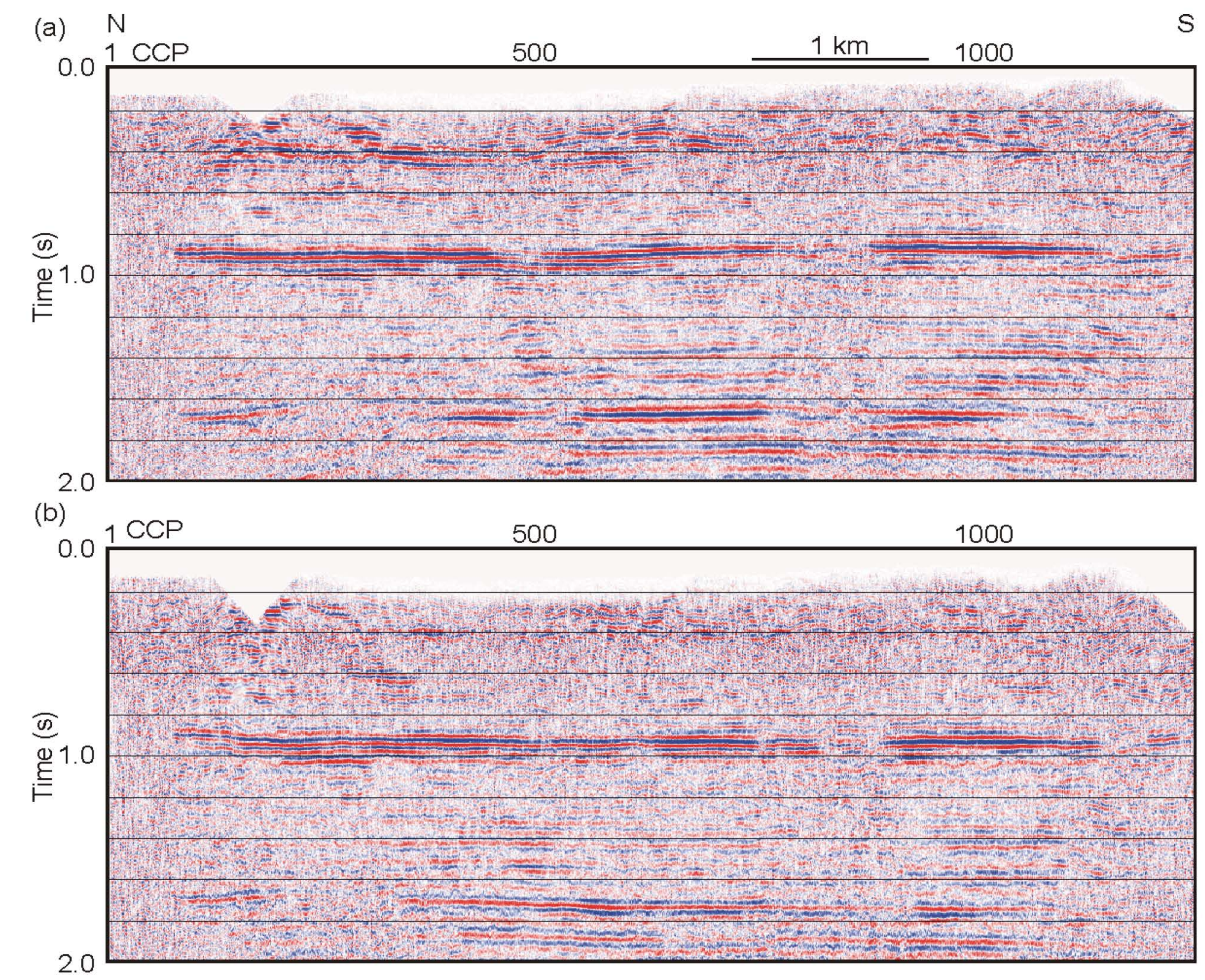

FIG. 5. Two receiver stacks with different statics calculated from the difference between the shallow picked horizon and a smoothed version of that horizon. The smoothing operator length for (a) was 501, while for (b) the horizon was flattened.

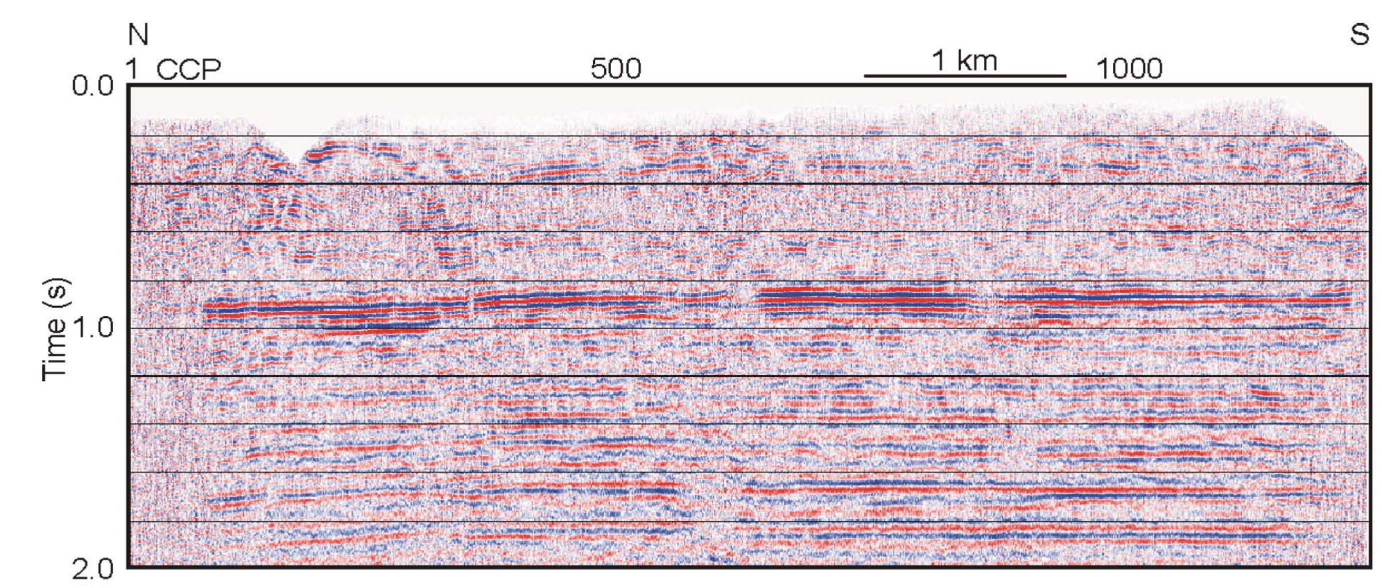

FIG. 6. The best CPP stack we could achieve. The receiver statics were the average statics for both horizons with a smoothing length of 331.

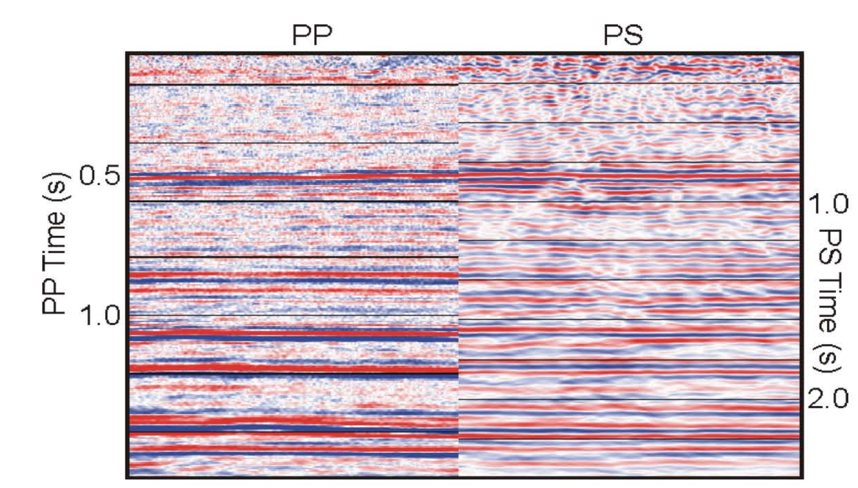

FIG. 7. Vertical (left) and radial (right) poststack migrated sections scaled to match reflectors. The polarity of the radial section was reversed to match the vertical section.

SUMMARY

We investigated the estimation of radial component receiver statics by the method of picking a horizon (or two) and calculating the statics necessary to shift the data to a smoothed version of that horizon. The amount of lateral smoothing had a surprisingly strong effect on the final stacked CCP converted-wave section. We found our efforts became somewhat hit and miss as we tried different smoothing operator lengths and compared the results visually. We also compared results using one horizon versus the average of two horizons and found better continuity of both reflectors when using both horizons.
Stacking velocities were not addressed in this study and they also affect the continuity and coherency of reflectors on the CCP section. We used a single simple velocity function for NMO removal.

For future work, we would like to create a synthetic dataset with severe receiver statics problems and test various methods of statics estimation.

CREWES

www.crewes.org

UNIVERSITY OF CALGARY