f-x statics

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ABSTRACT

A technique of solving statics without velocity information is developed in the f-x domain. The major different of this technique from the conventional one is the correlation model is built from the f-x prediction rather than a velocity dependent CDP stack trace. It is tested on a structural Marmousi dataset with promising results. This technique is believed to be especially important in solving statics for the structural converted wave data, without depending on the asymptotic common conversion point binning.

INTRODUCTION

The conventional method of solving residual statics problem is based on the work by Ronen and Claerbout (1985). In their approach, the surface-consistent residual statics are estimated by maximizing the stack power of a CDP stack, however, the error in the statics is sensitive to the velocity error. In their paper they said " statics estimation is effectively a velocity analysis of the near-surface. Ideally, statics and velocity analysis would be done together ". In practice, the velocity and statics are solved iteratively. This iterative procedure works well provided that the first velocity estimation is reasonable. However, in a complex structure regime, reasonable velocity estimation in the presence of larger statics may not be possible. Furthermore, the assumption of hyperbolic moveout curves in the CMP domain is violated in the complex structure. The maximum stack power, hence, may not reflect the proper statics. The problem may be even worse for converted-wave data. Because of the asymmetric moveout in the CMP domain, converted-wave receiver statics are solved in the asymptotic common conversion point (ACCP) domain instead. However, this type of binning requires a priori estimation of a constant Vp/Vs ratio. In complex structure, ACCP binning may not be applicable at all. In this paper an alternative method of solving statics in the common offset, f-x domain is proposed, in hope that the need for the velocity information and the hyperbolic movout assumption can be avoid.

THEORY

The basic assumption of this new statics calculation is that the underlying geological structure has certain degrees of smoothness. Because of this assumption, the image in each common offset plane is also smooth. However, because of the near surface statics, the image becomes jitter, in each common offset plane, in a surface consistence manner. However, this jitter can be considered as random error superimposed on the smooth events. From the knowledge of the linear prediction in the f-x domain (Canales, 1984), the smoothness of the events can improved by filtering out the jitter in each common offset plane with the f-x prediction filter. Therefore, instead of building a correlation model from a velocity dependent CDP stack trace, as in Ronen-Claerbout algorithm, the model can be built alternatively from the velocity independent f-x-prediction in the common offset domain. Once the models are created for all offsets, they are correlated with the original corresponding traces to find the static shifts. These static shifts are then decomposed into shot and receiver components and are solved in a surface-consistent manner. The process may be iterated to improve the statics solution.

EXAMPLE

A synthetic structural example from the Marmousi model is used to demonstrate the new static program. A brute velocity function was first picked from 5 CMP locations along the line of the statics-free data. This function is used for all sequence tests. The brute stack of the statics-free is shown in Figure 1. Next, random, surface-consistent shot and receiver statics are introduced. The maximum shot and receiver statics are 30 ms each. These data are stacked and the result is shown in Figure 2. Figure 3 is the stack after applying the statics derived from Ronen and Claerbout's algorithm. Because of the size of the statics, cycling skipping occurs, especially at both ends of the line. In the middle of the line, the structure is so complicated that the hyperbolic assumption is violated, and the statics solution is fail there. The Ronen and Claerbout's algorithm is modified to allow to summing 3 CMPs to build a super stack pilot track. The result of the stack is shown in Figure 4. The quality of the stack is improved, especially on the right hand side. It is because by summing 3 CMPs together, it helps the quality of the pilot trace when the dips are gentle. In Figure 5, the stack is obtained by first applying the proposed velocity independent statics, obtained from the fifth iteration, on the prestack data, followed by NMO and stack. The quality of the stack is tremendously improved, even in the middle of the structure, where the hyperbolic assumption breaks down. Figure 6 is the velocity spectrum of the statics-free data, at CMP station 2225. Figure 7 is the velocity spectrum after the statics are introduced. It is clear that the velocity function is very difficult to pick. Figure 8 is the velocity spectrum after applying the Ronen and Claerbout statics. The statics solution tries to satisfy the given velocity function and forces the CMP to be hyperbolic, even though the CMP is not, and hence give rise to the cycle-skipping. Figure 9 is the velocity spectrum with our f-x statics applied. The similarity between Figures 6 and 9 suggest that the velocity function can now be picked with confidence. This also suggests that the Ronen and Claerbout statics algorithm can be followed to further improve the statics. The semblance and the final stack are shown in Figures 10 and 11.

CONCLUSIONS

A new technique of solving statics without velocity in the f-x domain has been developed. It is shown to work on a complex structural dataset. The combination of the new statics method and the Ronen and Claerbout's method can be very useful in solving statics in a complex structure environment. The new method also has a good potential to solve for converted wave receiver statics.

REFERENCES

Canales, L. L., 1984, Random noise reduction: Presented at the 54th Ann. Internat. Mtg., Soc. Expl. Geophys., Expanded Abstracts, 525-527.

Ronen, J. and Claerbout, J., 1985, Surface-consistent residual statics estimation by stack power maximization: Geophysics, 50, 2759-2767.

ACKNOWLEDGEMENTS

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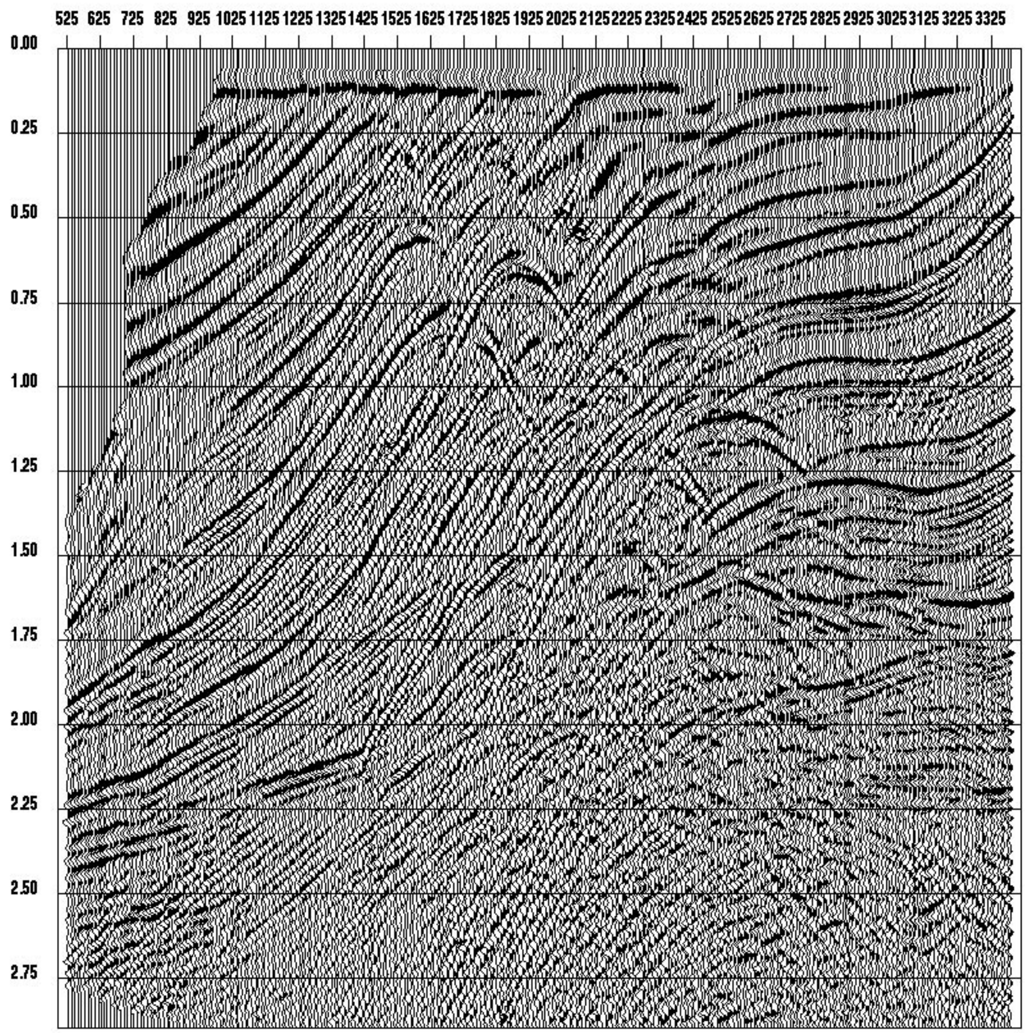

Fig. 1. The stack of the statics-free Marmousi data.

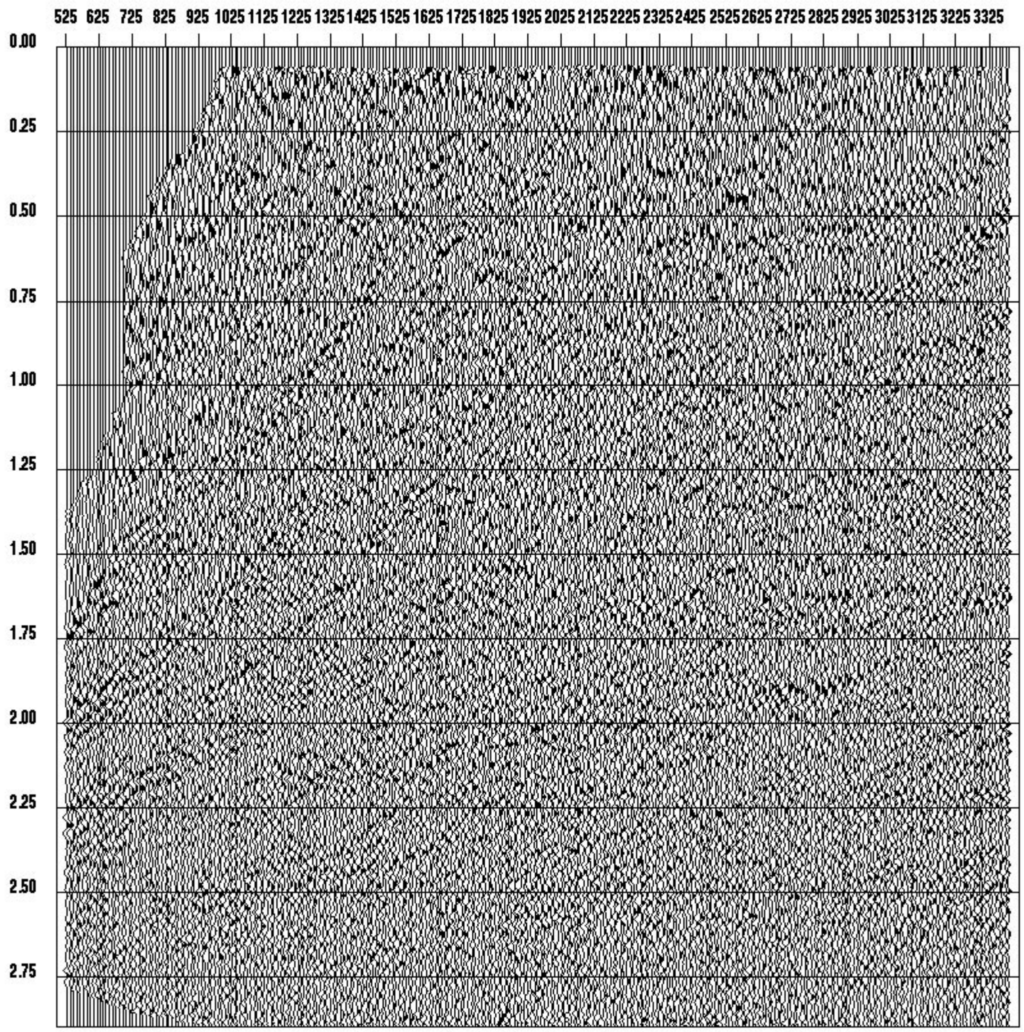

Fig. 2. The stack of the Marmousi data after introducing maximum 30 ms random statics for both shot and receiver.

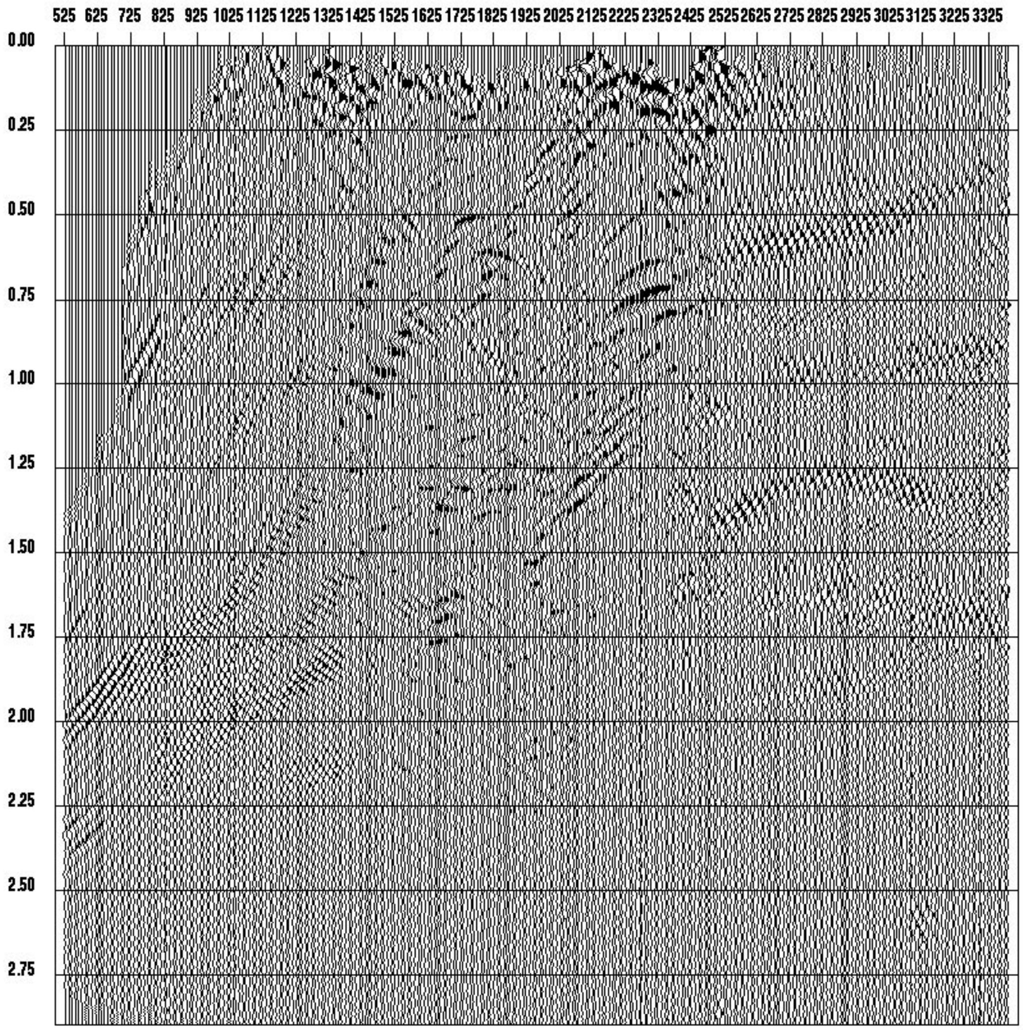

Fig. 3. The stack of the Marmousi data after applying the Ronen and Claerbout's statics. Because of the size of statics, cycle skipping occurs everywhere especially at both ends. The structure in the middle is so complex that it is not improved by the statics.

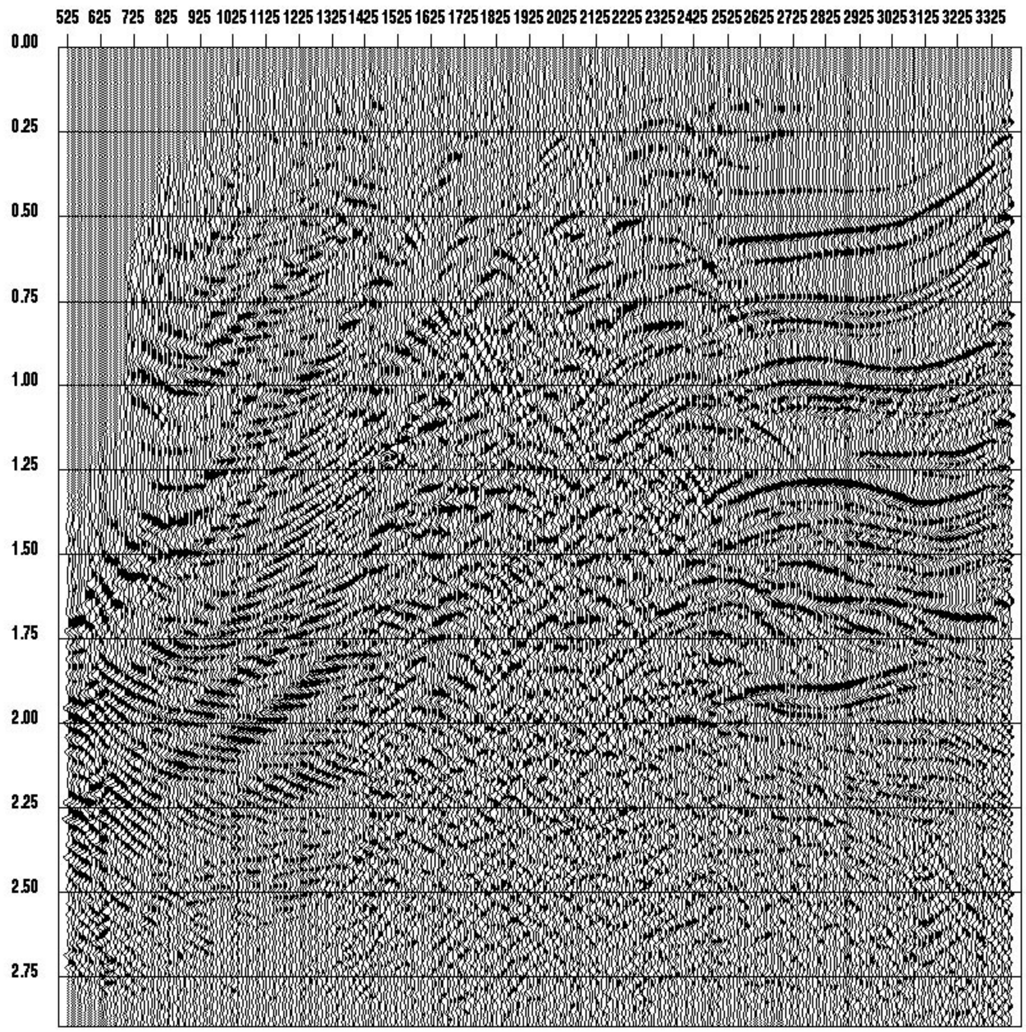

Fig. 4. The stack of the Marmousi data after applying the modified version of Ronen and Claerbout's statics. 3 CMPs are used to build the pilot trace. The effect of cycle skipping is lessened especially on the right hand side of the data where the dips are gentle.

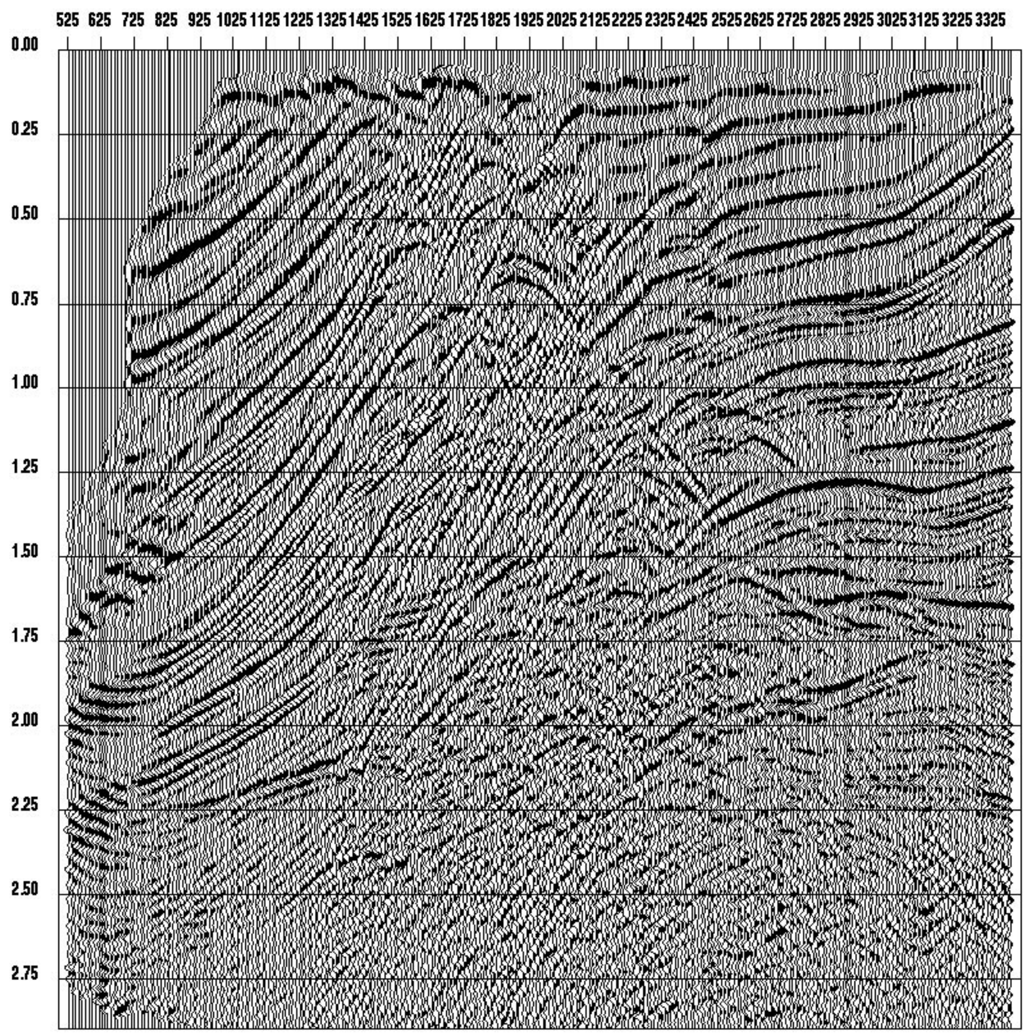

Fig. 5. The stack of the Marmousi data after applying the f-x statics. The complex structure starts showing up.

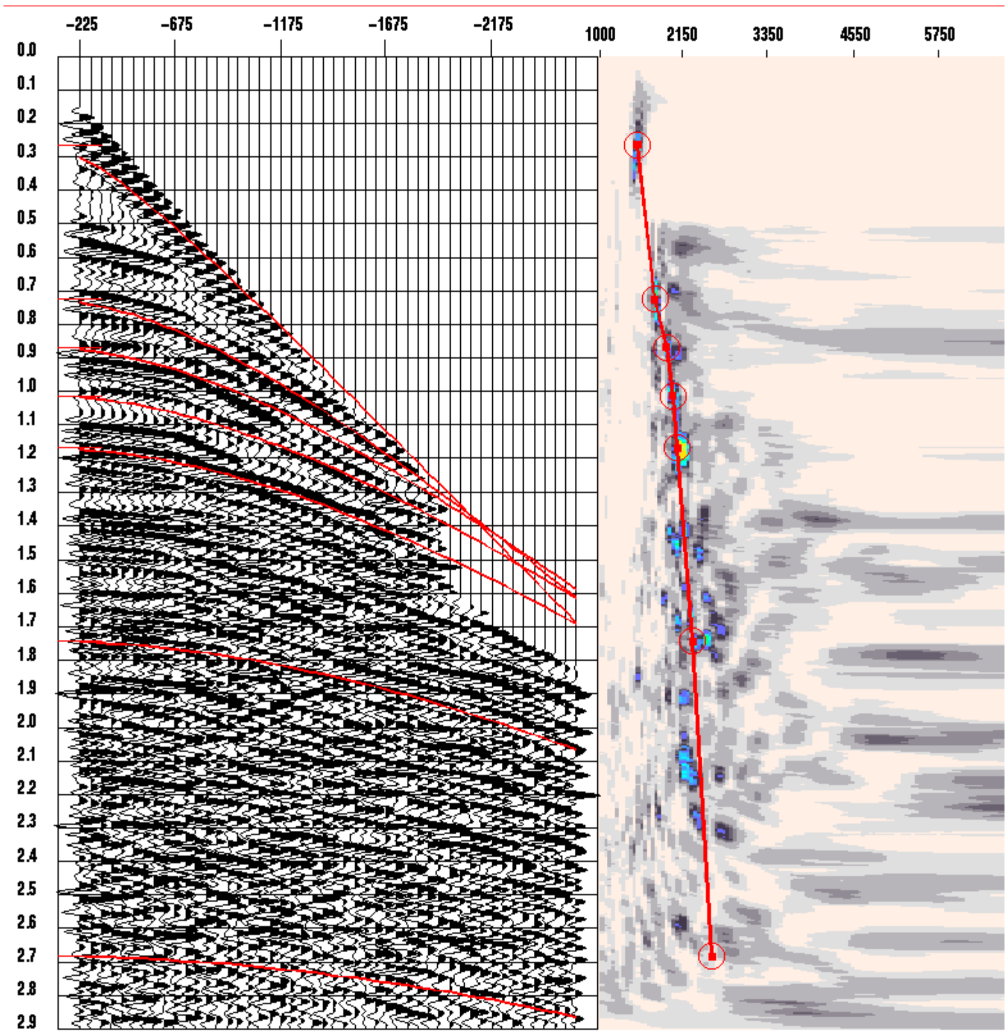

Fig. 6. The velocity semblance of the statics-free data at station 2225. A brute velocity function is picked as a reference for the test.

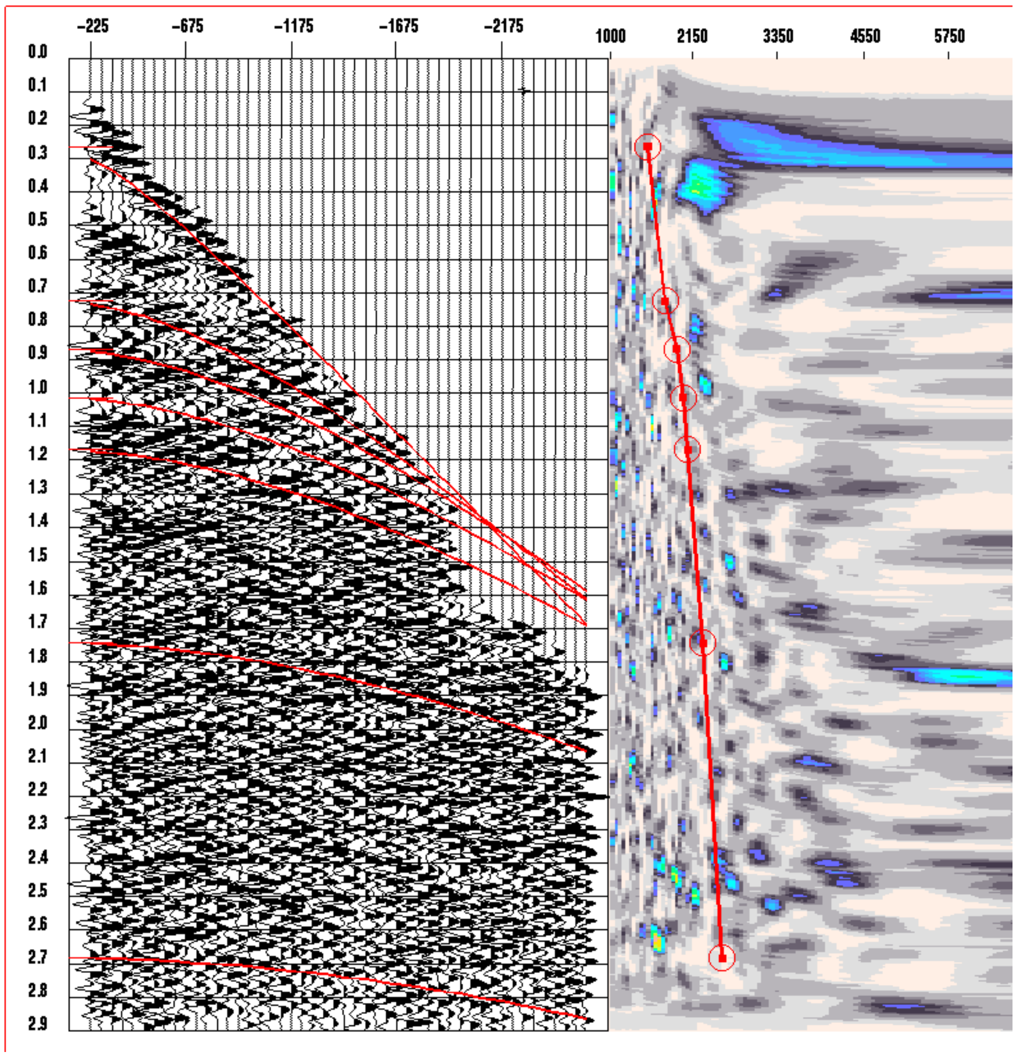

Fig. 7. The velocity semblance after random statics applied. A velocity function is difficult to pick.

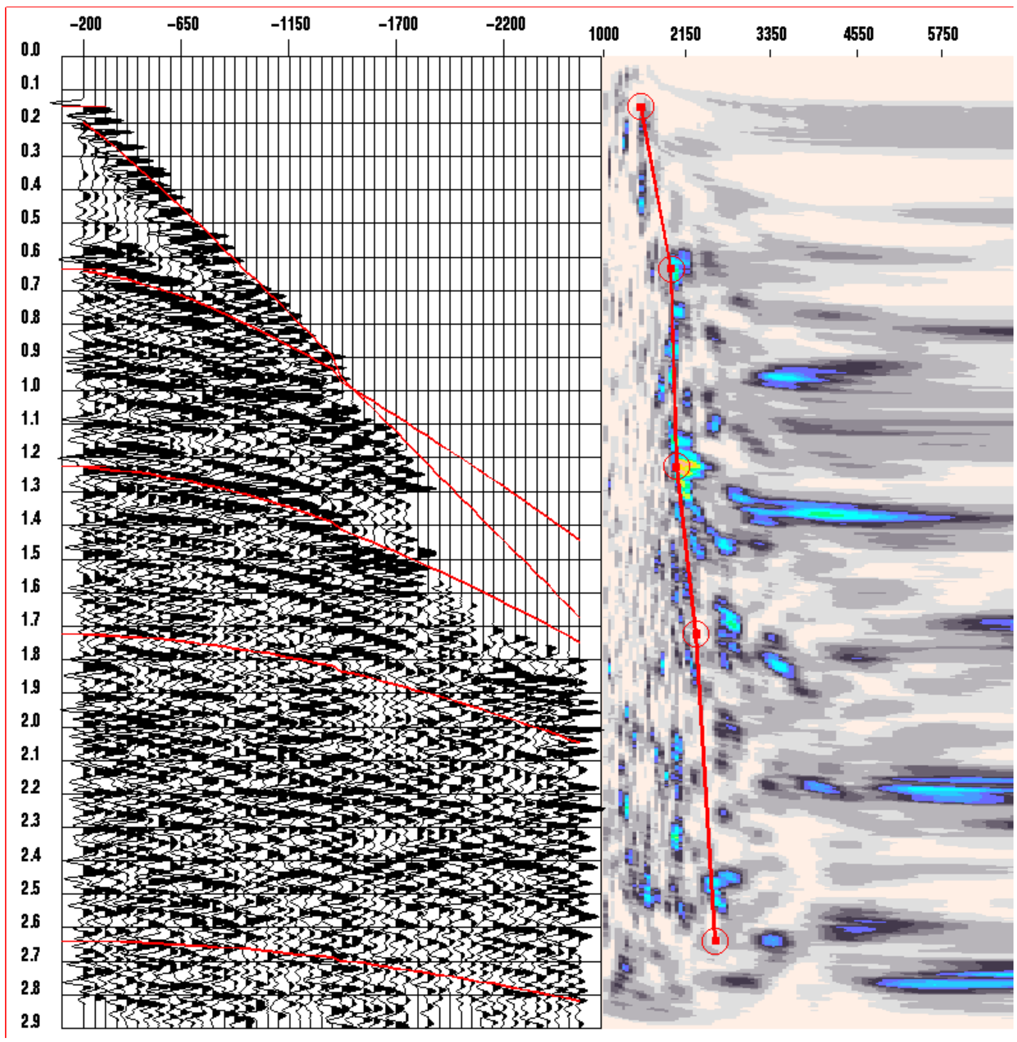

Fig. 8. The velocity semblance after applying the Ronen and Claerbout's statics. Cycle skipping is seen within the CMP.

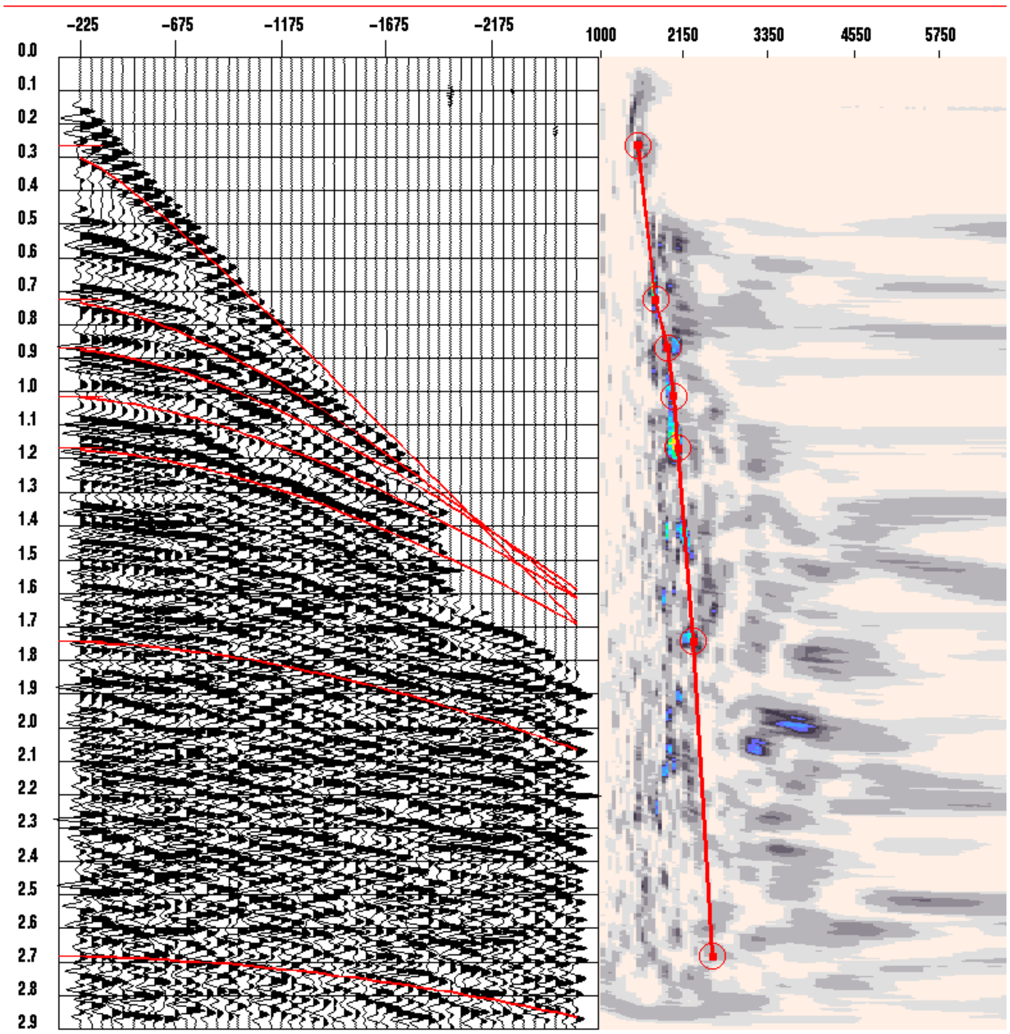

Fig. 9. The velocity semblance after applying the f-x statics. The semblance reveals a similar velocity function as the reference.

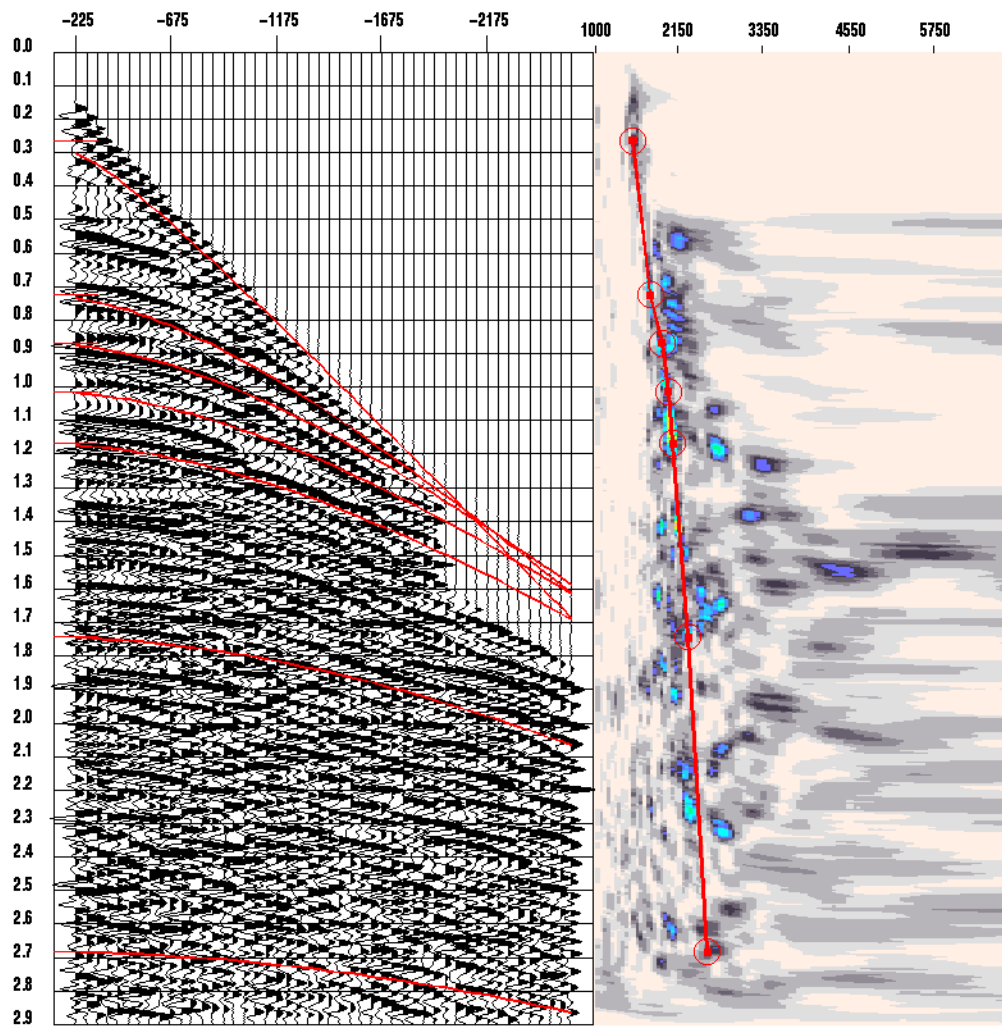

Fig. 10. The velocity semblance after f-x statics and the modified Ronen-Claerbout statics.

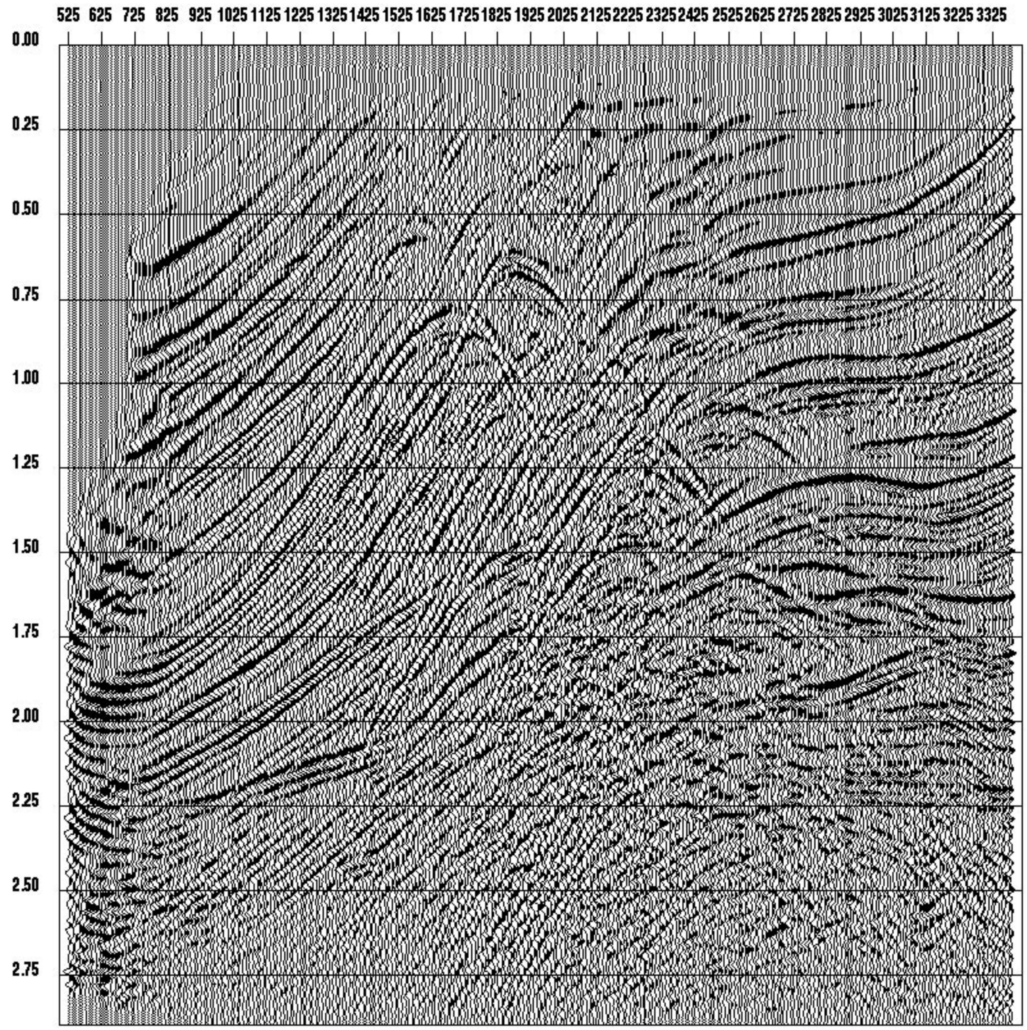

Fig. 11. The stack of the Marmousi data after applying the f-x statics and the modified Ronen-Claerbout's statics. The diffraction patterns in the middle of the line now show clearly.