

Term paper – Fall 2008

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ABSTRACT

Here, I show part of the activities developed during the Fall quarter of 2008.

INTRODUCTION

For the further development of the prestack-exploding reflector model (PERM) project as a tool to speed up migration velocity analysis it is important to apply it to a complex velocity model. The BP benchmark velocity model offers several challenges for both imaging and velocity model estimation. To test PERM, I have chosen a portion of this synthetic model, where shallow low-velocity anomalies occur. These velocity anomalies simulate confined channels with high pore pressure.

Preliminary results are showed, addressing the possible challenges of the further application of PERM on real data.

RESULTS

Figure 1 shows the correct velocity model for the portion of the BP benchmark model (Billette and Brandsberg-Dahl, 2005) where the shallow low-velocity anomalies occur. These velocity anomalies were edited out, resulting in the background velocity model presented in Figure 2.

Migrating with the edited background model leads to complex moveout, similar to that described by Toldi (1985), but in the context of determining interval velocities from stacking velocities in the presence of strong lateral velocity variations. Common image gathers (CIGs) in the subsurface-offset domain immediately below the edited low-velocity anomalies show reflectors curving down which characterizes migration with a slower velocity. CIGs in the vicinity of the former show moveout that characterizes migration with a faster velocity. Figures 3 and 4 exemplify the first case. They were migrated with the original and the background velocities, respectively. In Figure 4, notice that at depth of 2250m the energy is not concentrated at zero subsurface-offset and the reflectors are curving down in spite of the fact that the background velocity is faster than the correct velocity. The second case is showed in Figures 5 and 6, obtained with the original and edited velocities, respectively. Note that the reflectors at 2250m are now curving up, similarly to what occurs when migration is performed with a too high of velocity.

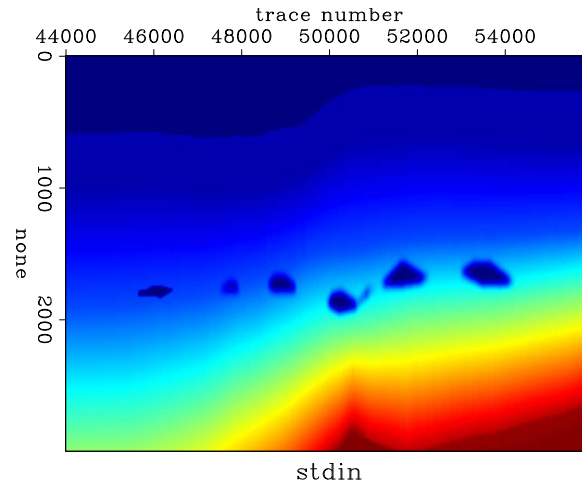


Figure 1: BP benchmark velocity model – Selected portion where shallow low-velocity anomalies occur.

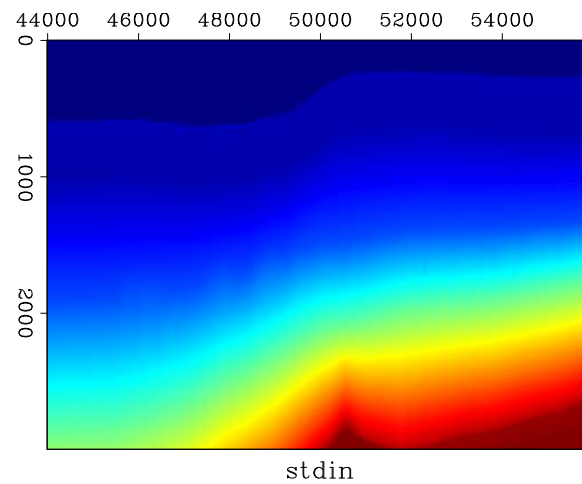


Figure 2: Edited BP benchmark velocity model – the shallow low-velocity anomalies occur were substituted by the background velocity.

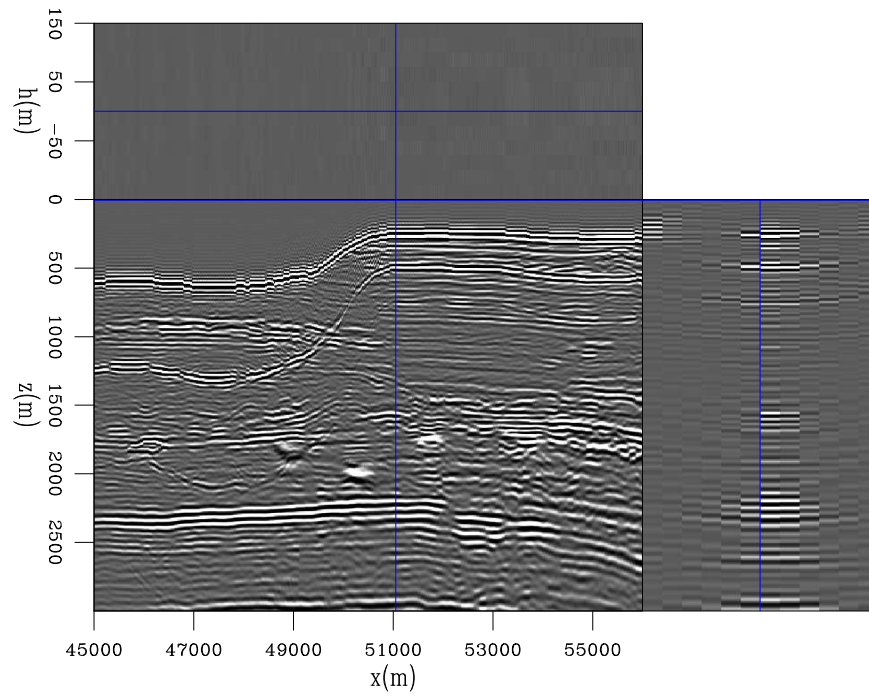


Figure 3: Prestack image computed with shot profile migration, using the correct velocity model. Compare with Figure 4.

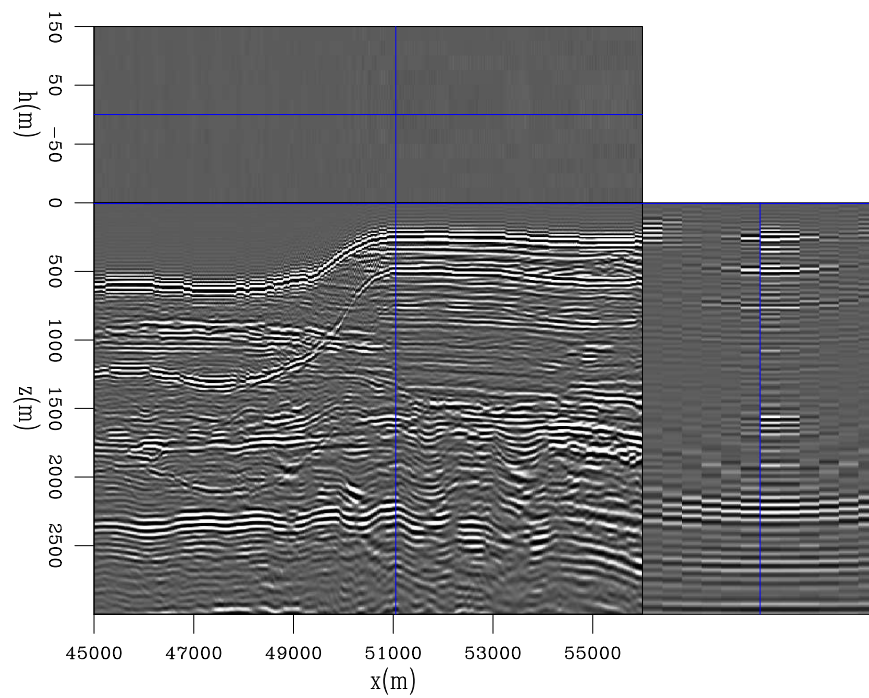


Figure 4: Prestack image computed with shot profile migration, using the background velocity model. Compare with Figure 3.

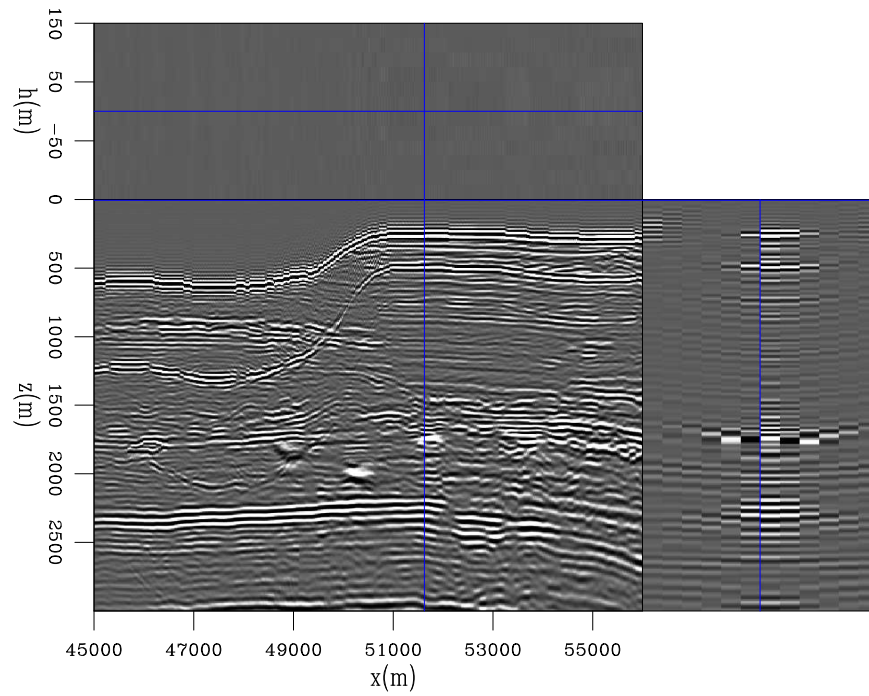


Figure 5: Prestack image computed with shot profile migration, using the correct velocity model. Compare with Figure 6.

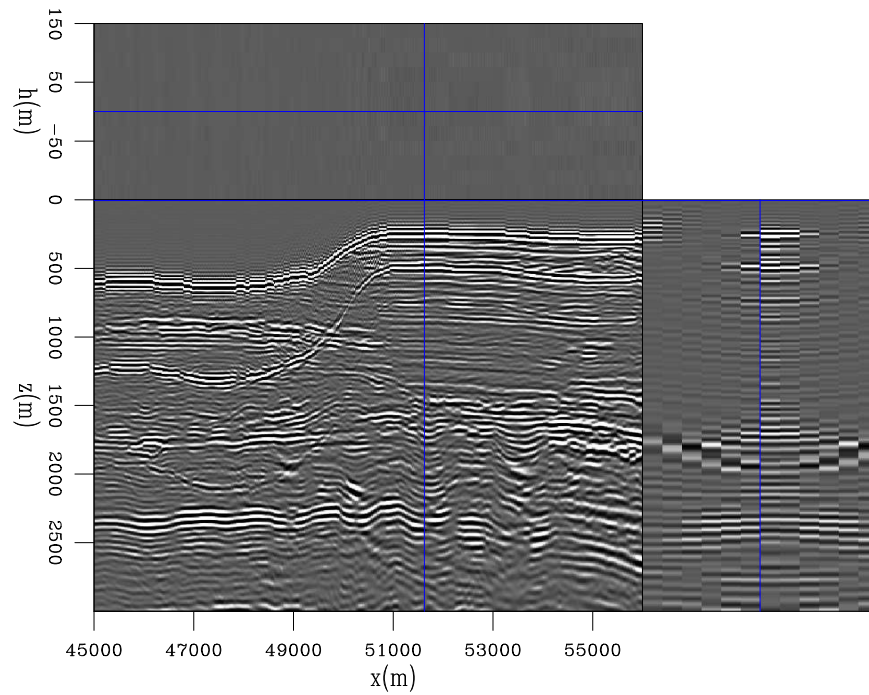


Figure 6: Prestack image computed with shot profile migration, using the background velocity model. Compare with Figure 5.

To apply PERM in the presence of several reflectors, it is necessary to select some representative reflectors. That is because the crosstalk during imaging becomes extremely strong when the initial conditions for PERM include many events. Starting from the migrated image with the edited velocity model, two sets of reflectors were picked in the prestack data for the subsurface offsets -150m, 0m and 150m, ranging from the depths of 2250m to 2750m. The picks were interpolated for all CMP positions and all offsets between -150m and 150m. Figure 7 shows the picked set of reflector at the zero-subsurface offset section.

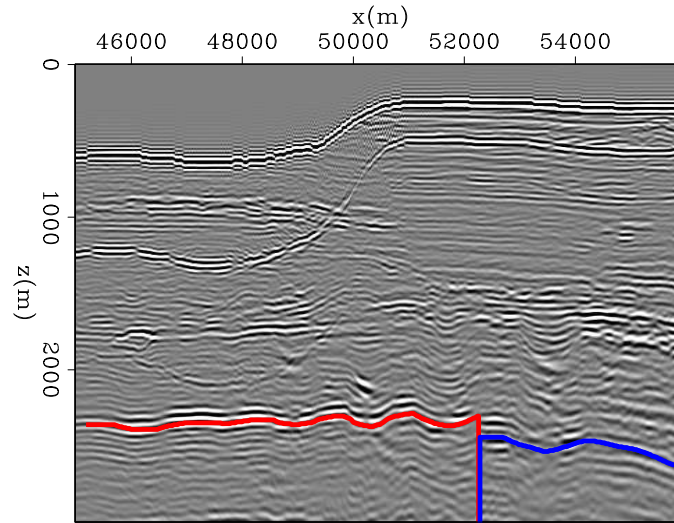


Figure 7: Picked reflectors at the zero-subsurface offset section.

The picking for subsurface offsets different from zero was challenging and prone to errors. Figures 8 and 9 show the picked reflectors at offsets -150m and -75m, respectively. For offset -75m the results were obtained by interpolation. As it is clear, the interpolation results are not perfect. For offset -150m, it is difficult to find a clear correspondence between picking and reflectors. An automatic picking procedure, similar to the strategy of Zhang and Claerbout (1990), constrained by manually picked events of small uncertainty will be a future work.

The picks are used to select events according to a window around them. The choice of the window size has a strong impact on the final quality of the migration of PERM data, as can be seen in Figures 10 and 11, which show the areal shot migration of PERM data computed using a window of 15 and 23 samples in depth, respectively. Bigger windows generates images with more ringing originated by spurious correlation between closely spaced reflectors, deteriorating the quality of the image.

To model PERM data, a the initial conditions for every super areal data were initiated at every 30th CIG. As the number of subsurface offsets of the background image is 13, no phase-encoding of the modeling experiments was necessary. Therefore, a total of 30 super areal data were generated. The PERM data was used as input to a non-linear velocity inversion. The image perturbation is computed using DSO, and

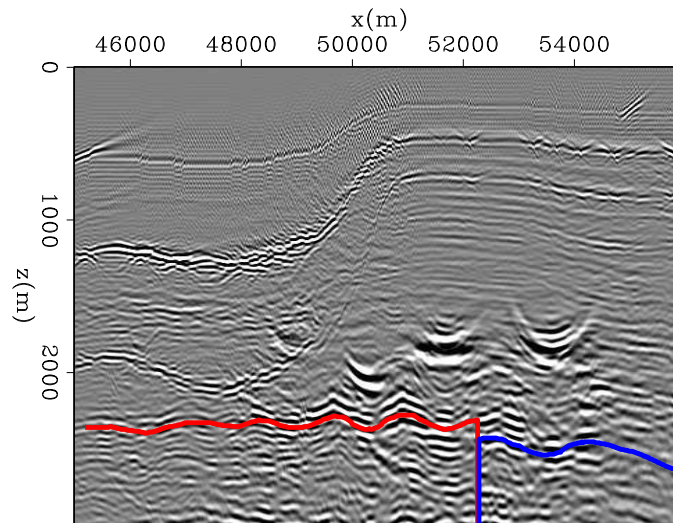


Figure 8: Picked reflectors at the subsurface offset -75m.

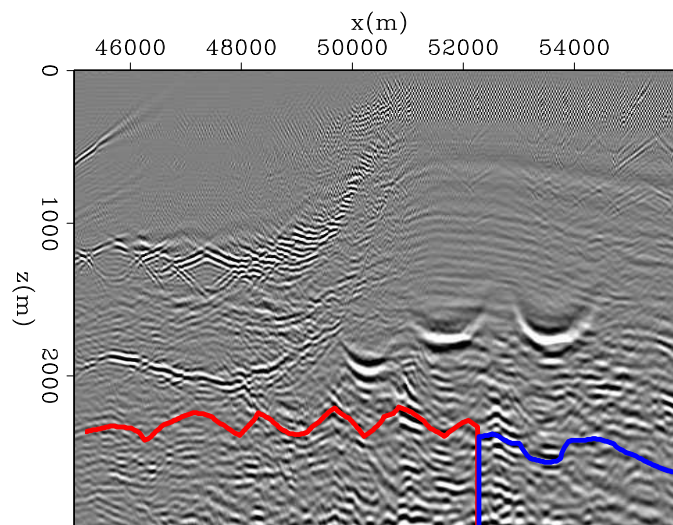


Figure 9: Picked reflectors at the zero-subsurface offset -150m.

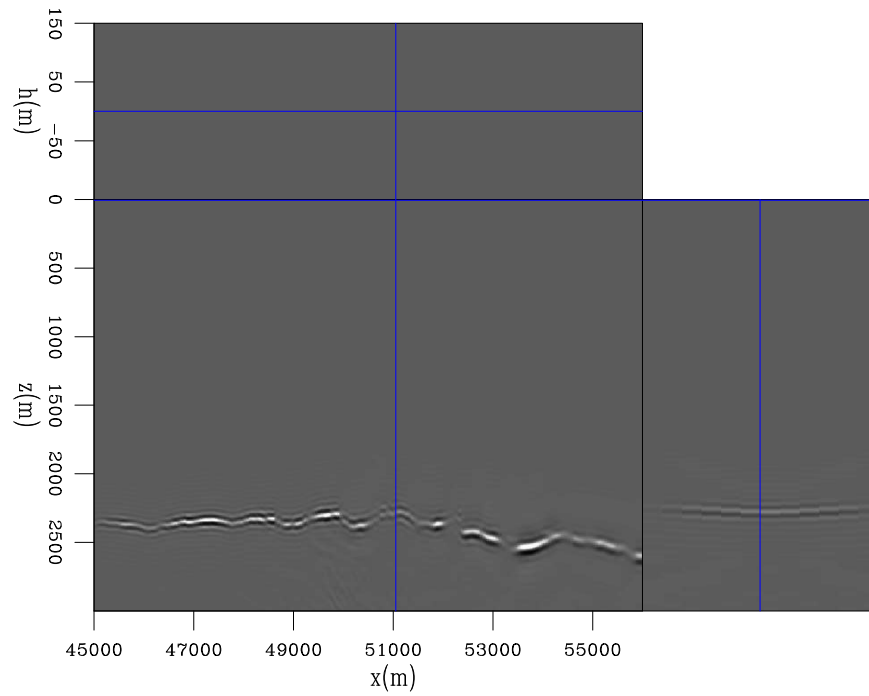


Figure 10: Areal shot migration of PERM data using a window of 15 samples in depth. Compare with Figure 11.

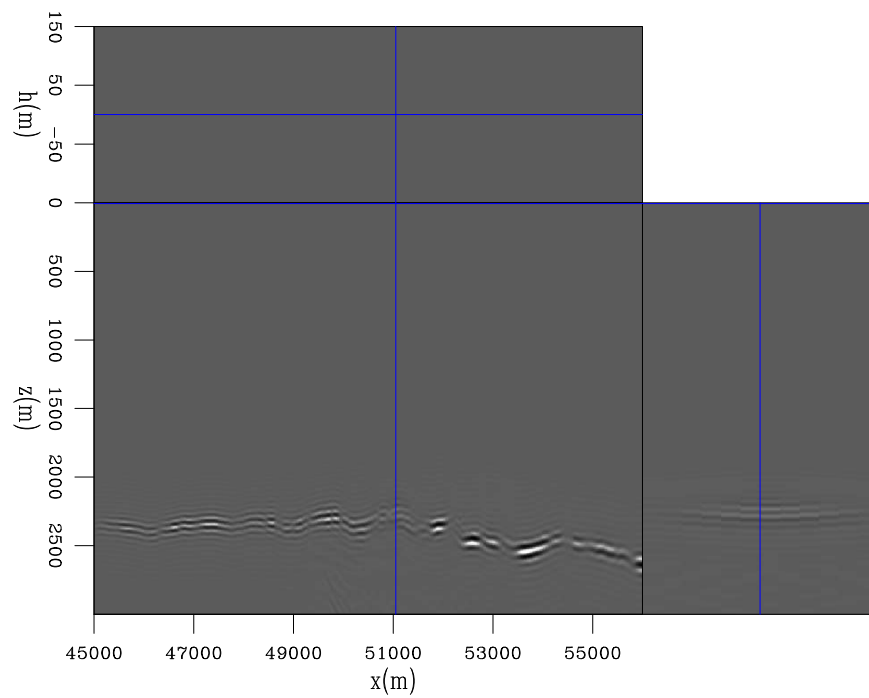


Figure 11: Areal shot migration of PERM data using a window of 23 samples in depth. Compare with Figure 10.

to minimize the objective function it is used L-BFGS algorithm (Nocedal and Wright, 2000). Figure 12 shows the negative of the gradient for the first non-linear iteration of the velocity inversion. Positive updates coincide spatially with the low-velocity anomalies. Negative updates, however, appear as side lobes caused, possibly, by the fact that no smoothness constraint was applied, like a B-spline parameterization of the velocity model, or by unbalancing of the migrated amplitudes along the CMP direction as can be observed in Figure 10. Further investigation of this problem and a revision of the inversion code are works to be done.

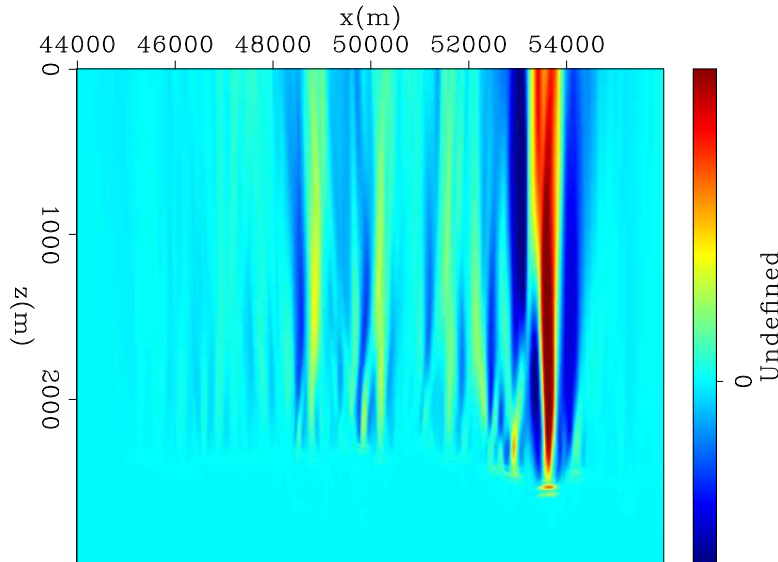


Figure 12: Negative of the gradient of the DSO objective function.

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