Internal multiple prediction on Hussar synthetics

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Abstract

The inverse scattering series internal multiple prediction algorithm is often called upon due to its unique ability to predict internal multiples with no subsurface information and without compromising the primaries. In this paper, we employ the 1.5D internal multiple prediction algorithm on Hussar synthetics. The synthetics are acquired by blocking the well 12-27 with different depth steps. We find that it can successfully predict internal multiples generated by the relatively thin layers of the Hussar geology (provided the interval between two primaries is larger than the optimal ϵ value). By extending the synthetic in offset, we see that certain prediction artifacts can be tied to land apertures.

1.5D internal multiple prediction algorithm

The formula for 1.5D internal multiple prediction (Weglein et al., 1997; 2003) is

$$b_{IM}(k_g,\omega)=\int_{-\infty}^{\infty}dz e^{ik_z z}b_1(k_g,z)\int_{-\infty}^{z-\epsilon}dz' e^{-ik_z z'}b_1(k_g,z') \times\int_{z'+\epsilon}^{\infty}dz'' e^{ik_z z''}b_1(k_g,z'') \qquad (1)$$

where $k_z=2q_g$ and the $q_g=\frac{\omega}{c_0}\sqrt{1-\frac{k_g^2c_0^2}{\omega^2}}$ is the vertical wavenumber associated with the lateral wavenumber k_g, the reference velocity c_0 and the temporal frequency ω. The quantity b_1 is the input to the prediction algorithm. And $z=c_0*t/2$ is the pseudo-depth defined in terms of reference P-wave velocity c_0 and vertical travel time t.

Hussar field experiment overview

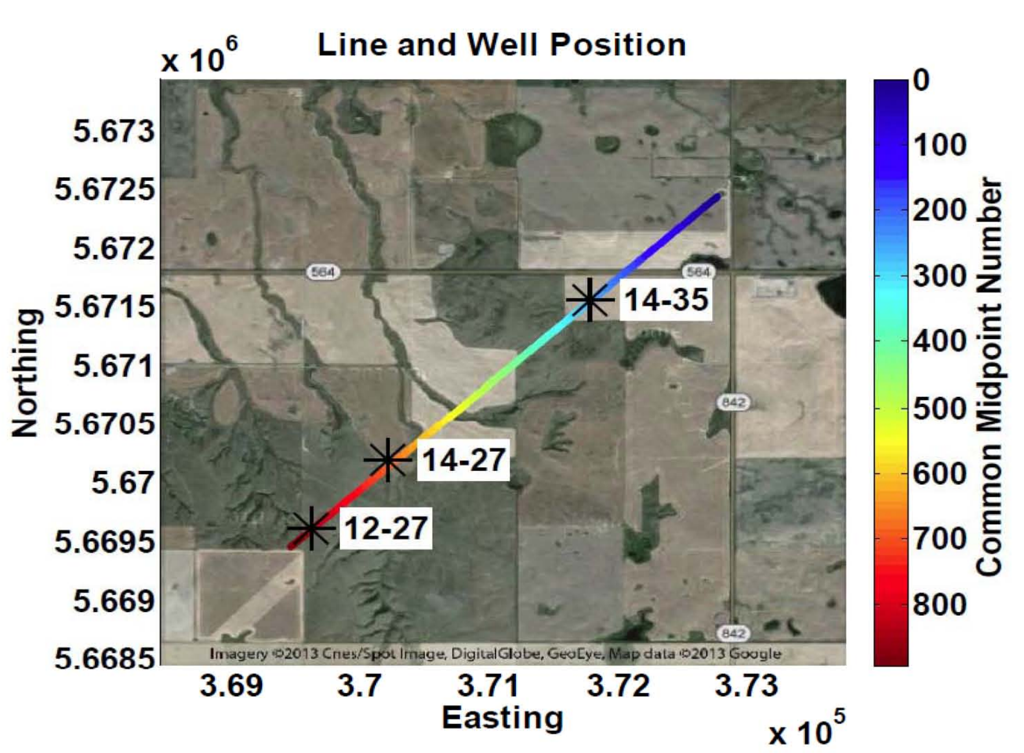

FIG. 1. The 4.5km Hussar seismic line is shown along with the locations of 3 wells (modified from Lloyd, 2013).

Hussar synthetics

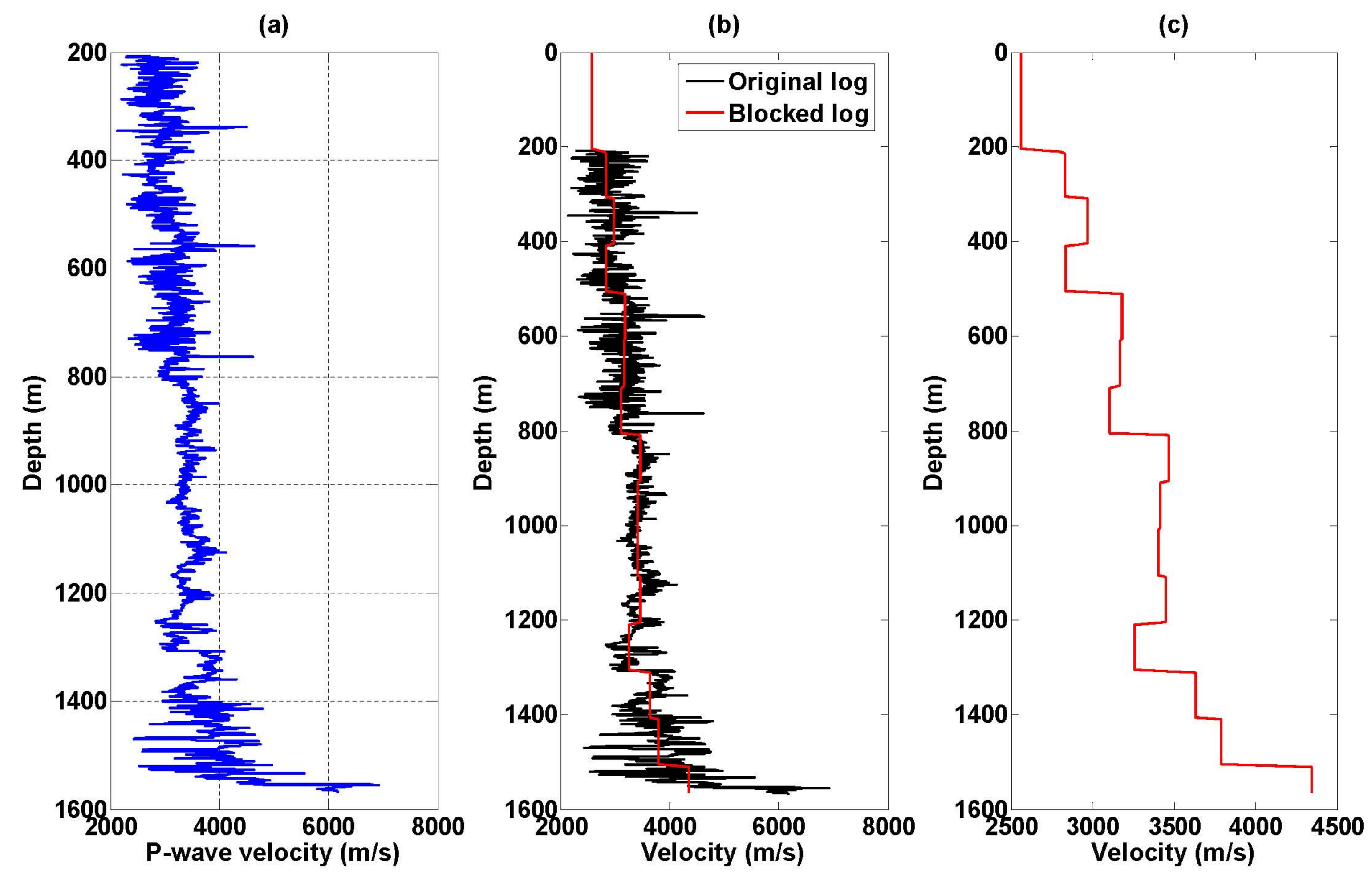

FIG. 2. (a) Well 12-27 P-wave sonic log ; (b) shows the original log in black and the blocked log in red; (c) shows only the blocked log. The depth step of the log being blocked is 100m.

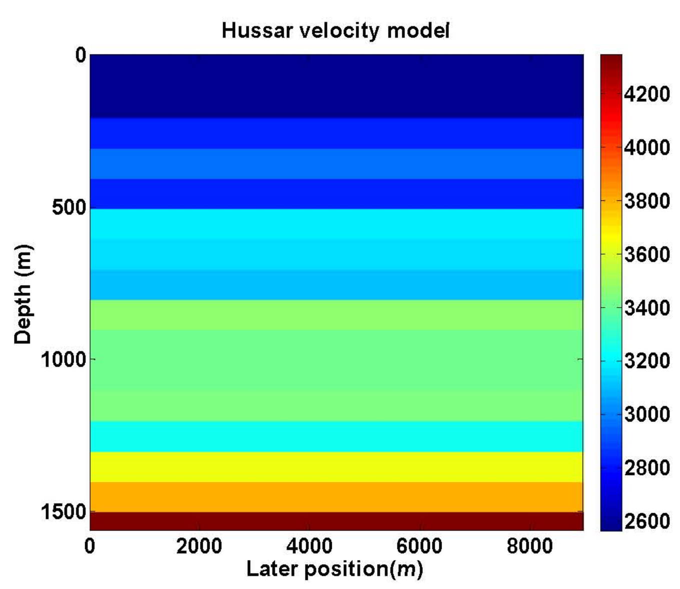

FIG. 3. Velocity model based on the blocked log.

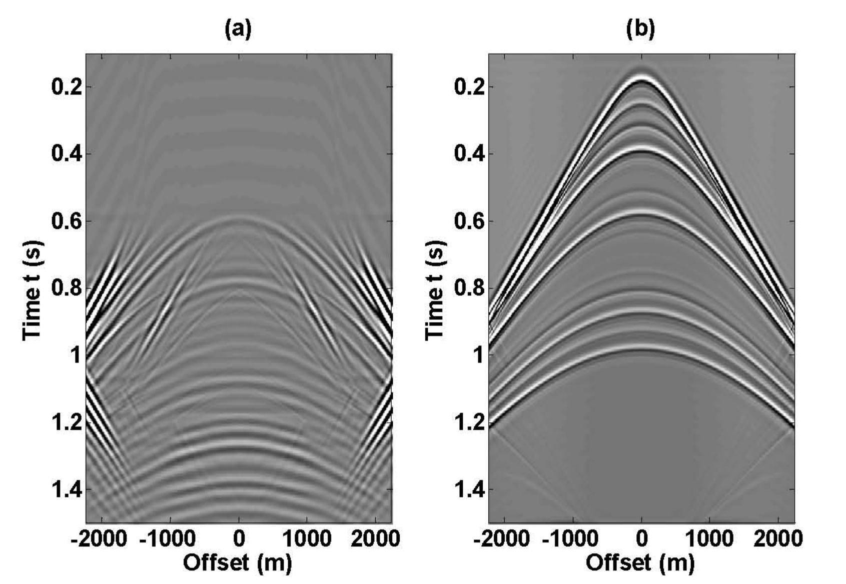

FIG. 4. Comparison of prediction output with input. (a) Prediction output; (b) input data.

- The first internal multiple (about 0.6s), which is interfering with a primary, has been correctly predicted.
- The kinematics of the internal multiples seems to be approximately correct.
- Artifacts become increasingly noticeable in the far offsets of the prediction record. One of the likely explanations for this is the aperture; we might inquire whether by increasing the offset we can reduce these artifacts.
- We simulate greater offset by increasing the source and receiver interval to be 10m (Figure 5b).
- Comparing Figure 5a with Figure 4a, we can see significant improvement in the prediction result.
- Far-offset artifacts can be effectively eliminated with acquisition changes; of course, these are not always possible, so we retain these artifacts on the list of real practical problems.

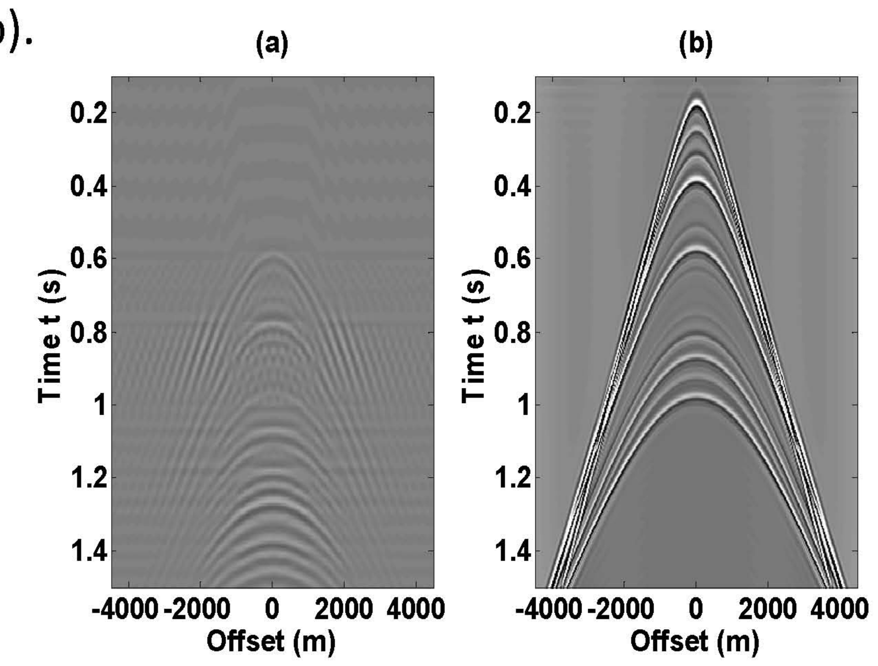

FIG. 5. Comparison of prediction output with input. (a) Prediction output; (b) input data.

Thin layers test

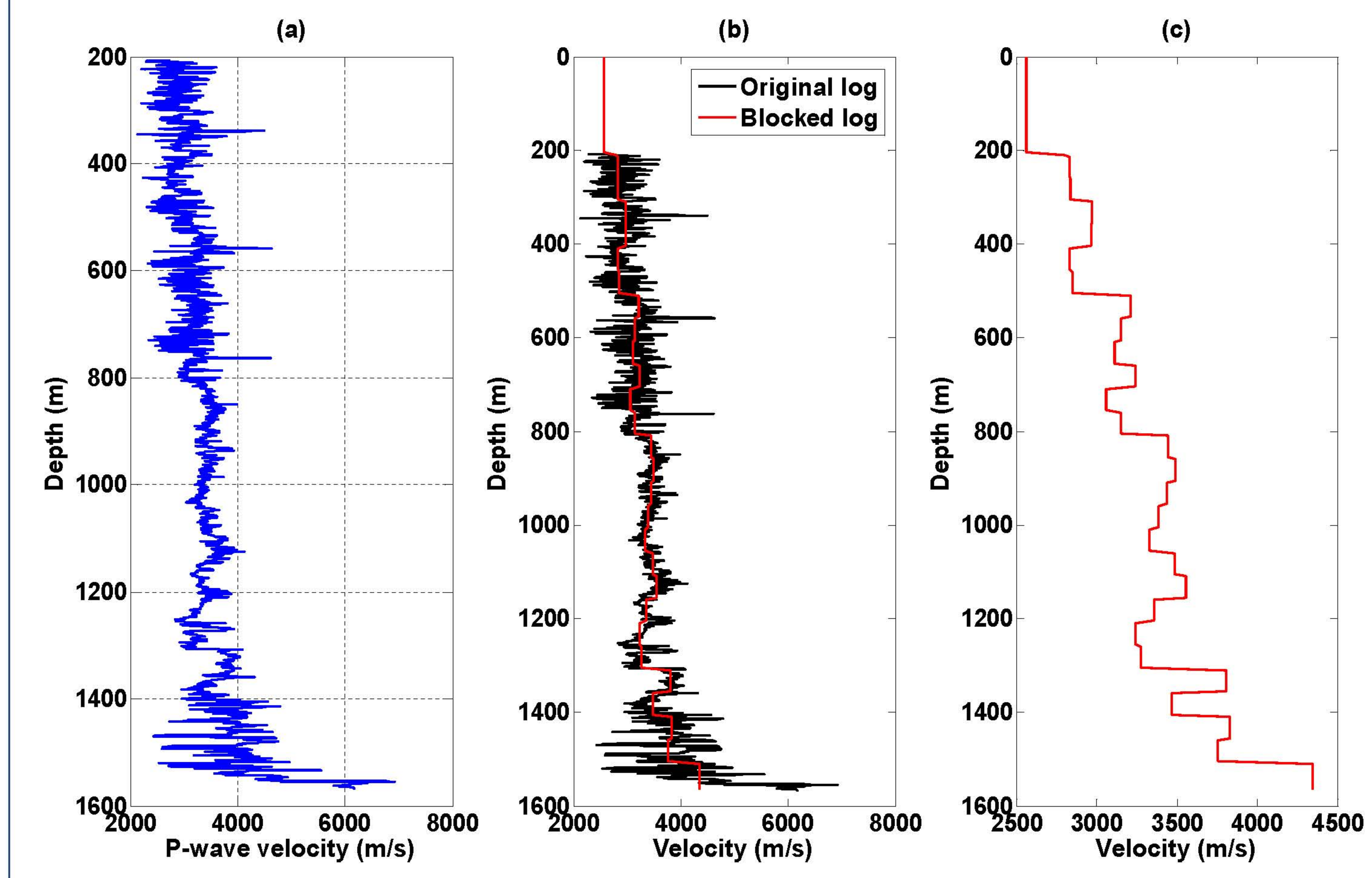

FIG. 6. (a) Well 12-27 P-wave sonic log ; (b) shows the original log in black and the blocked log in red; (c) shows only the blocked log. The depth step of the log being blocked is 50m.

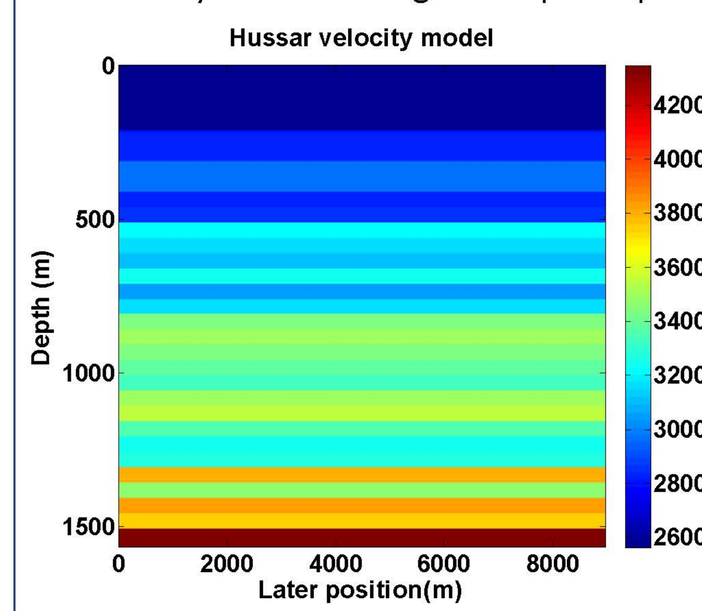

FIG. 7. Velocity model based on the blocked log.

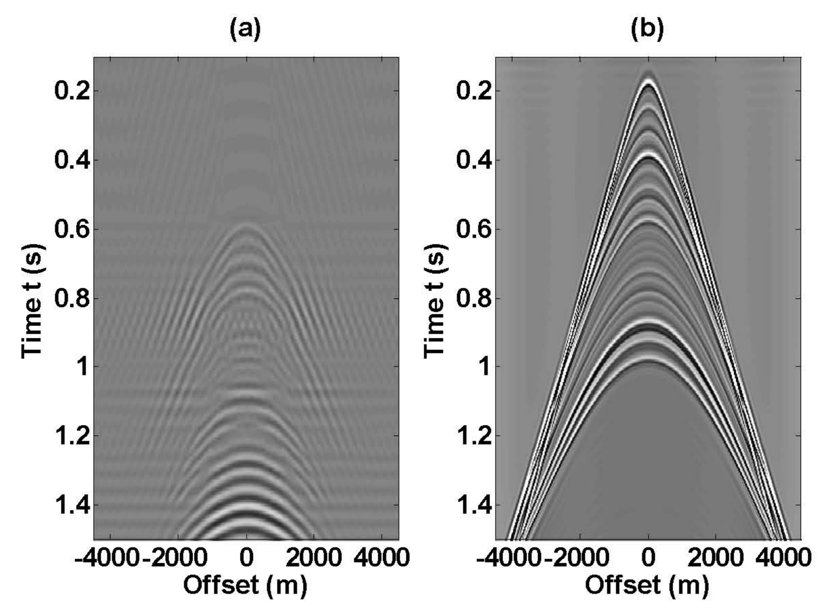

FIG. 8. Comparison of prediction output with input. (a) Prediction output; (b) input data.

- We decrease the depth step of the log being blocked to 50m.
- The model is composed of a large number of thin layers, with obvious presence of internal multiples in the data set.
- The performance of the 1.5D internal multiple prediction algorithm is still acceptable, especially at the zone between 0.6s and 0.8s since several internal multiples are interfering with primaries.

Conclusions

- This technology does not require velocity information from the subsurface or any advance knowledge of the multiple generators, and it predicts first-order internal multiples that are generated by all possible generators below the free surface.
- We find that it can successfully predict internal multiples generated by the relatively thin layers of the Hussar geology (provided the interval between two primaries is larger than the optimal ϵ value).
- By extending the synthetic in offset, we see that certain prediction artifacts can be tied to land apertures.

Bibliography

Please see the corresponding CREWES reports for a full bibliography.