High resolution residual velocity analysis and application

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ABSTRACT

Fidelity of velocity analysis is very important for seismic data processing and interpretation. Traditionally, velocity analysis produces estimates on a coarse grid and relies on interpolation. Accuracy can be improved by manually picking on a finer grid, although doing so becomes increasingly impractical with larger datasets. Amplitude-orientated kinematics (A-OK) provides an automatic method of residual velocity analysis for every CDP and every time sample. This method is based on the theory (Swan, 2001) that a quadratic phase mismatch between AVO intercept and gradient occurs when the velocity applied to the seismic gather is incorrect. In the first step, AVO attributes are calculated from the NMO corrected seismic gather. A-OK then calculates a velocity correction based on the degree of mismatch between these attributes. Finally, the original velocity is updated with this correction to create a new velocity field. The above procedure may be iterated a few times to get an optimal velocity field. This new field is high resolution because A-OK is applied to every CDP and time sample. Real data results show that A-OK is efficient and can correct velocity errors of up to 10%. Moveout correction of the seismic data with the high resolution velocity field yields a flatter gather. This leads to a more accurate image and more reliable AVO attributes. Furthermore, this high resolution velocity field gives a good starting point for a detailed reservoir characterization study and pore pressure prediction.

Introduction

Velocity analysis is time consuming. It is impractical to pick velocities at every CDP point. Traditionally, velocity analysis is performed on a coarse grid and interpolation is applied for CDPs between the manually picked velocity locations. There is no guarantee of a correct velocity for every CDP and time sample. For high quality seismic processing and detailed reservoir characterization, a more efficient way is needed to obtain an accurate high resolution velocity analysis. Amplitude-orientated kinematics (A-OK) provides an automatic method of residual velocity analysis on every CDP and every time sample.

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Methodology

Swan (2001) published an automatic method for velocity correction based on the measurement of quadratic phase mismatch between AVO intercept and gradient. Under some assumptions, when NMO velocity is correct, the AVO intercept and gradient either have the same phase or are 180 degrees different. When the NMO velocity is not correct, the AVO intercept and gradient are out of phase (*Fig. 1*). By measuring their quadric phase difference, a velocity correction (residual velocity) can be calculated and is used to update the original NMO velocity.

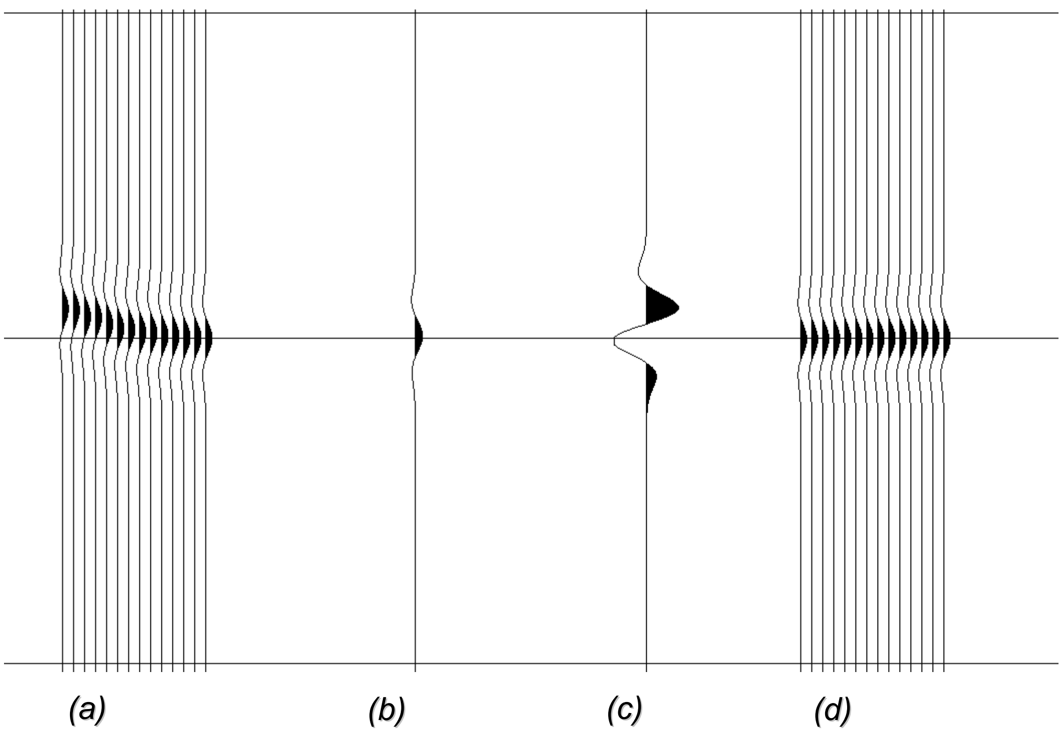

Fig. 1. The phase mismatch of AVO intercept and gradient can be used to calculate a correction of the NMO velocity. (a): a gather NMO corrected with an incorrect velocity (offset increases from right to left); (b): AVO intercept calculated from the gather in (a); (c): AVO gradient calculated from the gather in (a); (d): NMO corrected gather with a new velocity obtained from A-OK.

Based on Swan's theory, we developed a continuous residual velocity analysis method, A-OK, which measures the degree of phase mismatch between intercept and gradient and generates a velocity correction. A few iterations are needed to get an optimal velocity field for every CDP and time sample. Tests on real seismic data sets show that A-OK can correct velocity errors of up to 10%.

Field data example

A-OK has been applied to a 3D project in Alberta, Canada. The velocity was manually picked. Then we added 2 – 3% errors to the original velocities on purpose to test the algorithm. *Fig. 2a* shows CDP gathers which are NMO corrected with incorrect velocities. It is obvious the gathers are under corrected. *Fig. 2b* shows the same gathers NMO corrected using the new velocities generated from A-OK. Two iterations of A-OK were applied. Most events are flat in *Fig. 2b*, except for the event at 1600 ms on the third and fourth gathers from the right side where the velocity is still a little bit too fast. This implies another iteration is needed. Figure 3 shows the stacked sections using the incorrect and A-OK updated velocities. The events are sharper and more continuous with the A-OK updated velocities.

Conclusions

A-OK is an efficient way to get an accurate high resolution velocity field. It can correct velocity errors of up to 10%. The seismic data processed with the high resolution velocities yields flatter gathers. This leads to a more accurate image and more reliable AVO attributes. Furthermore, this high resolution velocity field gives a good starting point for a detailed reservoir characterization study and pore pressure prediction.

Acknowledgements

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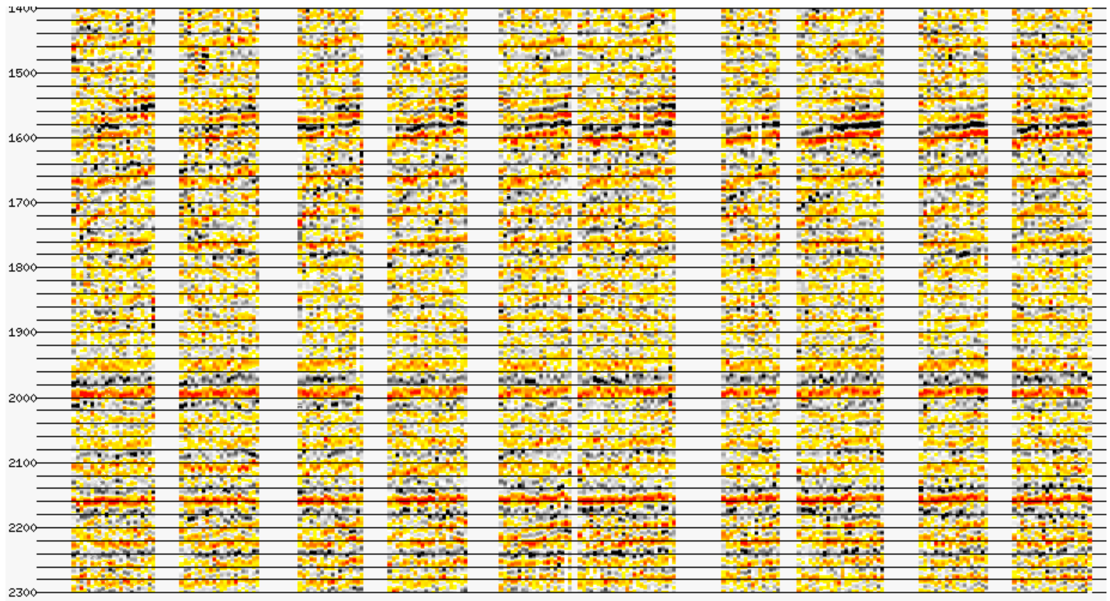
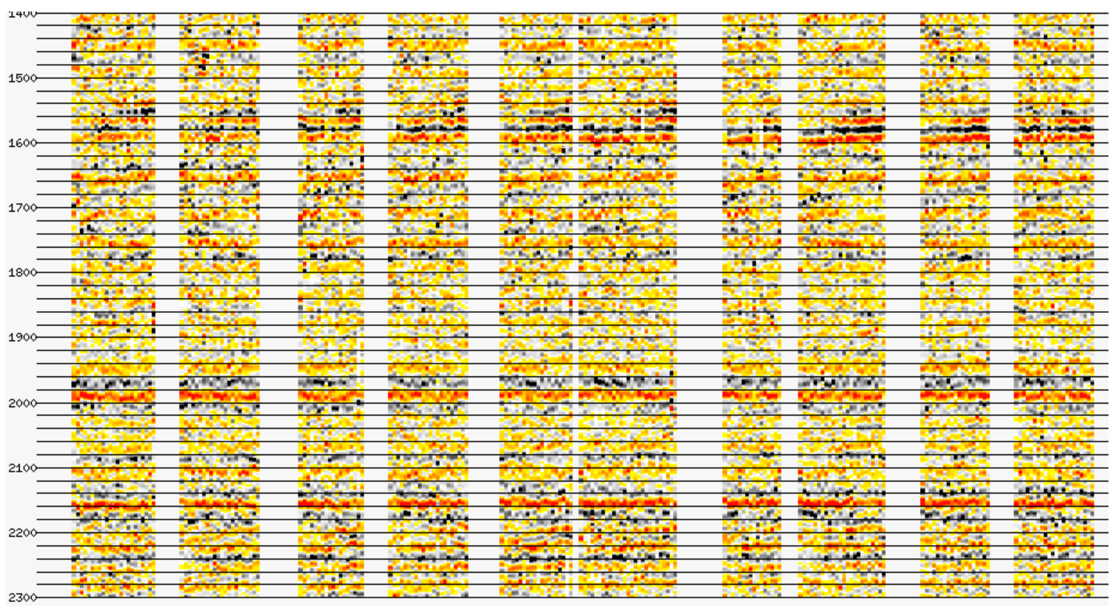
References

Swan, H.W., 2001, Velocities from amplitude variations with offset: Geophysics, **66**, no. 6, 1735-1743.

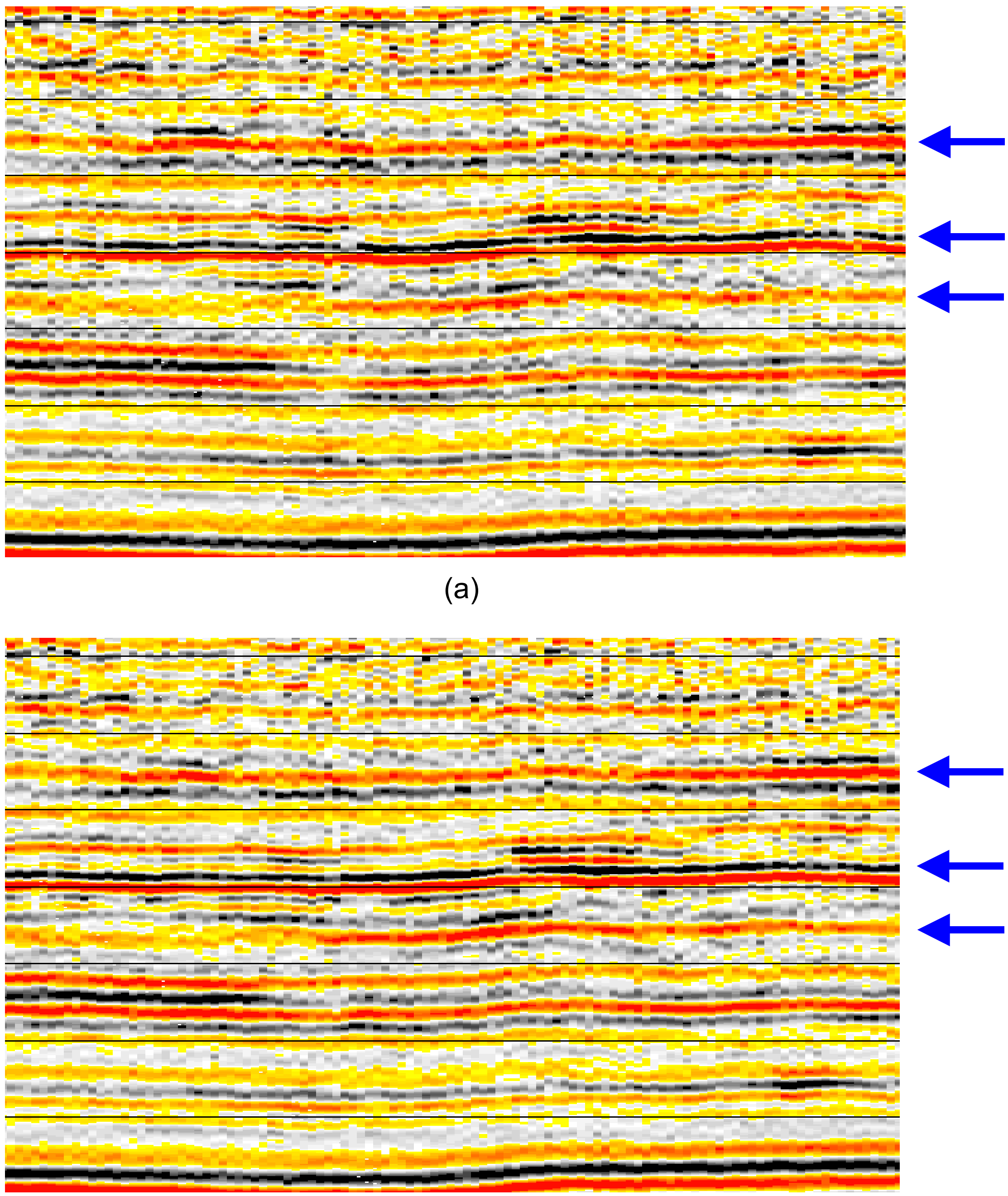


(a)



(b)

Fig. 2. (a) NMO corrected gathers with velocities that have 2 – 3% errors. Most events in the gathers are under corrected. (b) NMO corrected gathers with the A-OK updated velocities. Almost all events are flat, except for the third gather from the right side where the velocity is still a little bit too fast at 1600 ms, which implies another iteration is needed.



(a)

(b)

Fig. 3. (a) Stacked section with velocities that have 2 – 3% errors. (b) Stacked section with the A-OK updated velocities. Events are sharper and more continuous than in (a), especially for the events marked by blue arrows.