Optimizing Converted-Wave Prestack Time Migration

Peter W. Cary*
Sensor Geophysical Ltd, Calgary, AB, Canada
peter_cary@sensorgeo.com

and

Changjun Zhang
Sensor Geophysical Ltd., Calgary, AB, Canada

Summary

This paper reviews some technical issues, such as velocity and anisotropy parametrization, anti-aliasing, random noise attenuation and data regularization in converted wave (P-S) prestack time migration. We introduce a processing flow for common-offset-vector based prestack migration which handles the aforementioned issues appropriately and optimizes the imaging and velocity updating processes.

Introduction

For areas with gentle lateral velocity variation, Kirchhoff prestack time migration is an appropriate tool for imaging the subsurface. In converted wave processing, the correct parametrization and implementation of the migration algorithm are fundamental to obtain correct images. The prestack migration algorithm needs to account for the different intrinsic anisotropy of P and S waves and can also compensate for the different source and receiver datum. Moreover, random noise and irregular acquisition geometry need to be considered before migration.

Method

Travel time computation is essential for Kirchhoff prestack time migration (KPTM). We follow the works of Li (2001, 2007) and parametrize the double square root equation of converted wave travel-time using four parameters. They are converted wave RMS velocity Vc, vertical velocity ratio γ_0, effective velocity ratio γ_{eff} and anisotropy parameter χ. χ is not directly related to the Thomson anisotropy parameters ε and δ (Tsvankin and Thomsen, 1994), which is a non-physical parameter. The advantage of using Vc and velocity ratios instead of P-wave velocity Vp and S-wave velocity Vs in KPTM processing is that the travel-time of the PS-converted wave is not sensitive to variations in the velocity ratios. The effect of velocity ratio error on the move-out is much less than the effect of Vc error. In PS-converted wave data processing, the values of the velocity ratios obtained from stacking velocity analysis can be used in converted wave prestack time migration (CPSTM). Thus, only the PS-converted-wave velocity needs to be estimated precisely.

Like regular P-wave migration, migration aperture, amplitude weighting and migration operator aliasing are important factors for obtaining right migrated images. In converted wave migration, we need to pay special attention to aliasing problem, because the large difference between down-going and up-going velocities. The correct frequency limit, which is dependent on Vp and Vs, can be derived based on the P-wave formula (Lumley, 1994).

Our CPSTM is based on common offset vector (COV) processing (Cary, 1999). A COV gather is a selection of traces with common inline-offset and common cross-line offset. Our converted wave 5D interpolation moves energy across CMP and offset to regularize observation geometry and attenuate random noise at the same time. The regularized and random noise attenuated COVs are extremely useful for obtaining true imaging of the subsurface.

Velocity updating is critical for the imaging process which often requires several velocity picking and migration iterations. As aforementioned, converted-wave NMO velocity is the initial input and is the only parameter need to be picked at selected imaged locations.

Conclusions

The main issues of converted wave prestack time migration are the same as that in P-wave prestack time migration. The difference is that converted waves travel at different velocities in down-going and up-going directions, plus, converted wave experience more severe anisotropy. We reviewed issues in converted wave migration and presented a migration flow based on COV processing that optimizes P-S wave imaging.

References

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