Depth migration model building and model verification sequence

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The importance of using a correct velocity model for seismic migration process is not deniable. Nevertheless, even for the most sophisticated modern migration algorithms velocity model building is ignored or simplified to an interval seismic velocity. In this article, we will share a very simple and effective way of constructing velocity models for migrations and depth conversions. Also, we will show how radically better well known Kirchhoff Anisotropic Wavefront Propagation Depth migration result (based on proper velocity building model and appropriate applied pre-migration processing sequences) can be compared to depth migrated data by one of the modern algorithms.

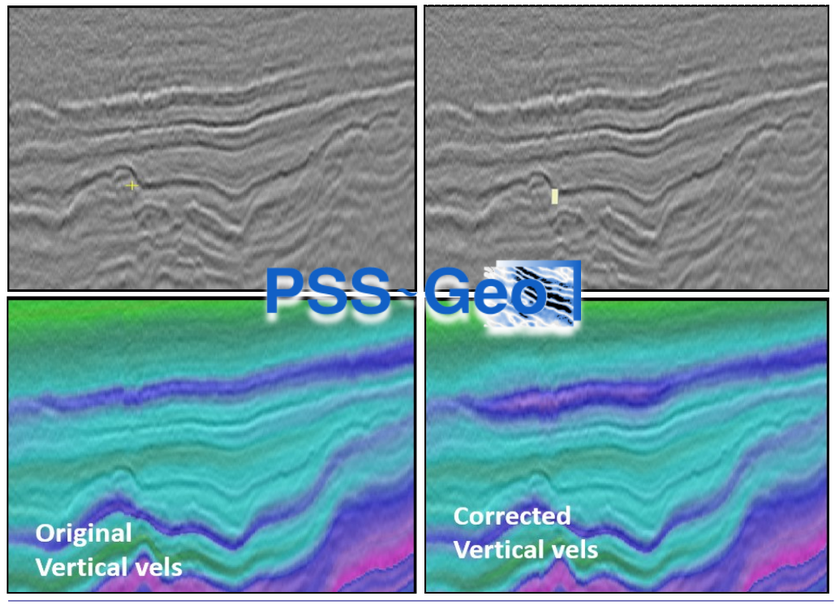
PSS-Geo provides Kirchhoff Anisotropic (TVI &TTI) Wavefront Propagation Depth migration from anisotropic interval velocity models. Such models are built in a step by step manner involving integration of diverse geophysical information in multiple iterations of imaging at progressively deeper depths to continuously update and verify the model.

Our methodology is based on the definition of a vertical interval velocity model and an anisotropy field. As a rule of thumb the vertical velocity field should represent a valid Time/depth function typically used for depth conversion in interpretation work; the anisotropy field should be congruous with surface seismic velocities as for its sub horizontal raypaths.

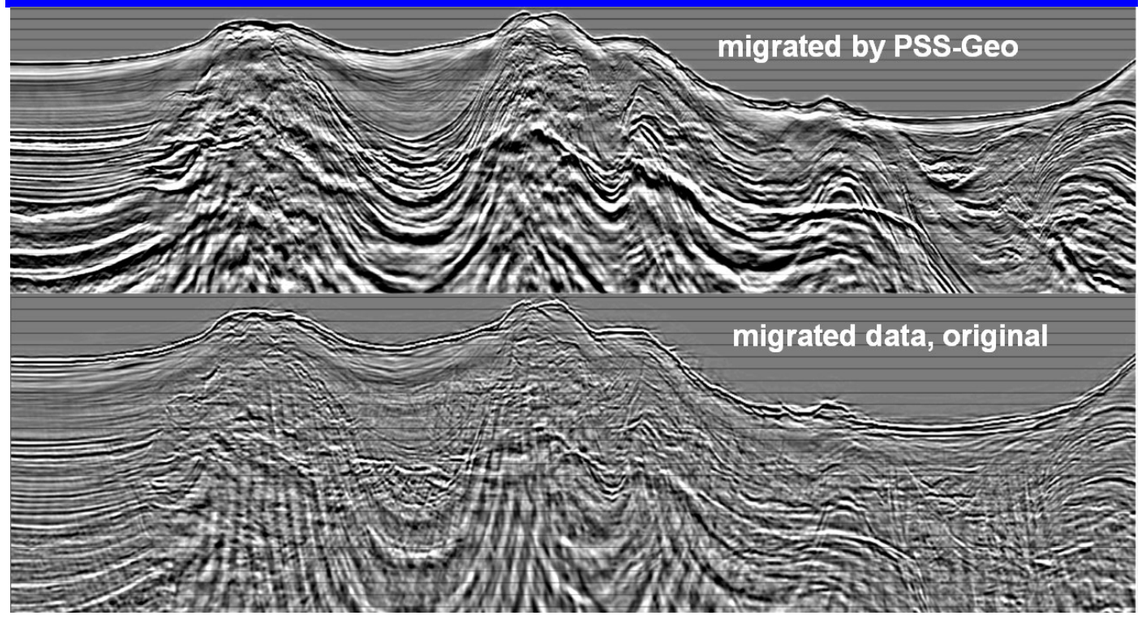
We are focused on the creation of models that are both correct in the time and depth relationship and highly plausible from the geological interpretive point of view. The objective of the anisotropic approach is to optimize the image quality - flat gathers - and to tie the main reflectors to the wells within 1% whilst still maintaining a geologically sensible spatial distribution of the velocities for each layer. A typical sequence will include a:

1) Building a starting interval anisotropic velocity model

- Build an initial vertical velocity model using suitable check-shots within the survey and time interpreted horizons. The check-shot could be verified/optimized by doing a well-tie to the PSTM stacks.
- An initial horizontal (anisotropy) velocity model can be derived using Dix converted and smoothed RMS velocities or from an isotropic V0 model with corresponding gradients (k).
- Near surface sub resolution velocity anomalies (pull-ups/down) can be detected and modelled to avoid distortion on deeper horizons.
- Depth migrate well tie or target lines. Measure anisotropy parameters in well positions, and build an anisotropy model. Typically initial anisotropy model is created interpolating the anisotropy between wells and supplied horizons. The anisotropy model can be updated/adjusted in each iteration to ensure correct depth in well positions is maintained.



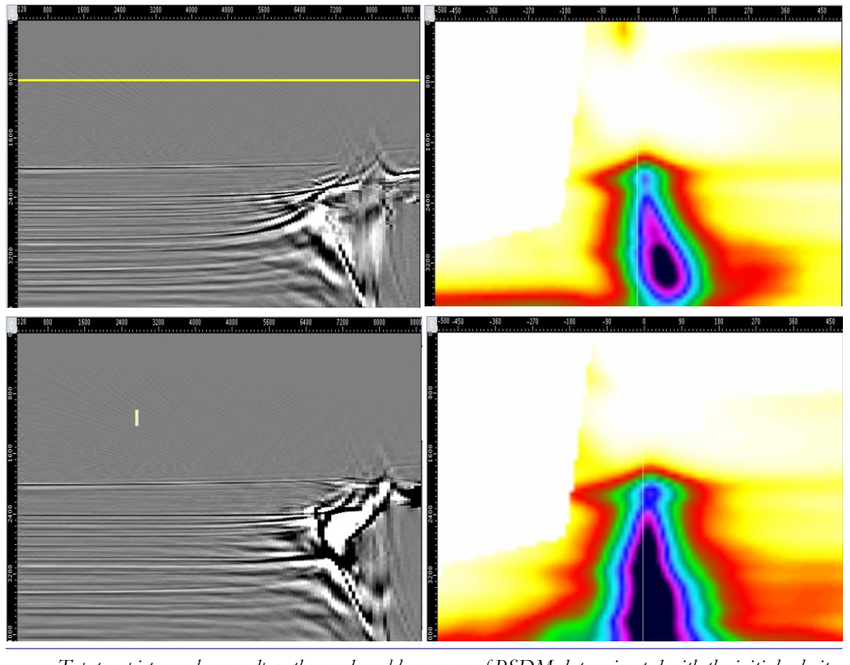
Original interval seismic velocity and corrected velocity models. Corrected velocity model built by using logs data and anisotropic VTI/TTI gridded tomographic solution trough iterations approach. Bottom right picture shows anomaly appearance. Top two pictures are original seismic data



Top picture is seismic data processed by PSS-Geo AS. Migration algorithm is old known Kirchhoff Anisotropic Wavefront Propagation Depth migration. Velocity model is corrected velocity model built by using logs data and anisotropic VTI/TTI gridded tomographic solution trough iterations approach. Bottom picture is the same seismic data migrated by modern algorithm with simplified velocity model.

2) Iterative tomographic inversion

- On progressively deeper volumes the data is depth-migrated using Kirchhoff migration, to an appropriate depth, using the current velocity model.
- Residual moveout are auto-picked on gathers. Such pick must be representative of primary energy: a Hi-Res Radon demultiple, or other process, might be used to increase moveout measure quality. Events must be geologically meaningful as displayed on imaged stack.
- The residual moveout picked on the velocity analyses is inverted to update the interval velocity field using an anisotropic VTI/TTI gridded tomographic solution.
- The number of iterations required defined by the complexity of the area involved and the consistency of results.



Top two pictures show a cdp gather and semblance scan of PSDM data migrated with the initial velocity model. Bottom pictures show the same cdp location this time migrated with the updated velocity model

The 3D Pre-Stack Depth Migration is tied to the key wells to confirm the accuracy of the velocity field and anisotropy parameters.

Our approach is flexible and can allow for continuous update of vertical and anisotropic velocity models and aim at a depth image consistent with well data.

Whether it is a new or old migration algorithm, PSS-Geo AS recommend to use presented above sequence for velocity model building. Variations of this algorithm can be used effectively for depth conversion and time migration.

In spite of the chain of process, the algorithm is still cheap and has reasonably quick velocity model building solution.