Simultaneous prestack inversion benefits from prestack seismic data conditioning

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Summary

Prestack seismic inversion techniques provide valuable information of rock properties, lithology, and fluid content for reservoir characterization. The confidence of inverted results increases with increasing incident angle of seismic gathers. As offset increases we often encounter "hockey sticks" and severe stretch at large offsets. Both "hockey stick" and stretch not only lower the seismic resolution but also hinder long offset prestack seismic inversion analysis. The inverted results are also affected by the random noises present in the prestack gathers. In this study we present a three-step workflow to perform data conditioning prior to simultaneous prestack inversion. We illustrate our workflow by applying it to a prestack seismic volume acquired over the Fort Worth Basin (FWB), Texas (TX), United States of America (USA). The results inverted from the conditioned prestack gathers have higher resolution and better correlation coefficients with well logs when compared to those inverted from conventional time migrated gathers.

Workflow and Geology background

The proposed workflow contained three steps. First, we mitigate the "hockey sticks" by using an automatic nonhyperbolic velocity analysis. Then we minimize the stretch at far offset by employing an anti-stretch workflow. Last, we improve the signal-to-noise ratio (SNR) by applying prestack structure oriented filtering.

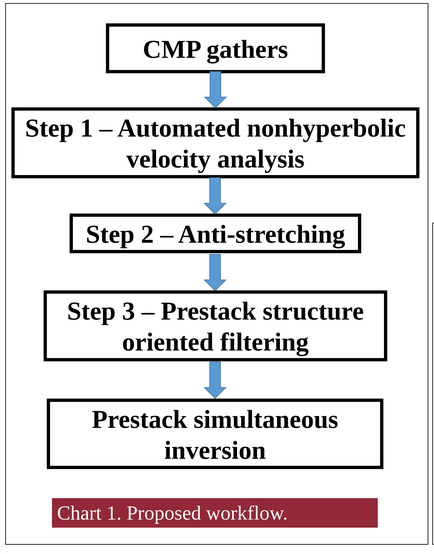

Chart 1. Proposed workflow.

The FWB is a foreland basin and covers approximately 54000 mi^2 in north-central Texas. The target is the Mississippian Barnett Shale which is one of the largest unconventional reservoir in the world and spreads approximately 28000 mi^2 across the FWB.

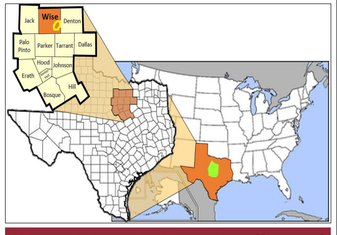

Figure 1. Location Texas in yellow and Fort Worth Basin in green. The Wise county is zoomed in in yellow.

Application

To illustrate the effectiveness of proposed workflow, we apply this workflow to prestack time migrated CMP gathers in the Fort Worth Basin (FWB), USA. The survey is located in Wise County and the maximum offset is around 14000 ft while the target Barnett Shale is approximate 7000 ft in depth.

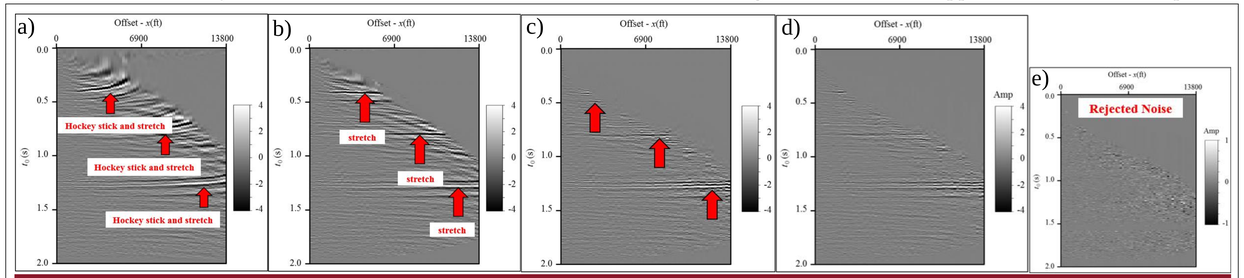

Figure 2. A CMP gather using prestack seismic data conditioning workflow. a) Time migrated gathers using hyperbolic travel equation. Note the "hockey stick" effect and stretch at far offset indicated by the red arrows. b) The same gather as in a) after time migrated gathers after nonhyperbolic velocity analysis. Note the flattened gathers are still stretched at far offset indicated by the red arrows. c) The same gather as in b) after nonstretch correction. Note the stretch is mitigated at far offset. d) The same gather as in c) after prestack structure oriented filtering (PSOF). e) Rejected noise by PSOF from the gather in d).

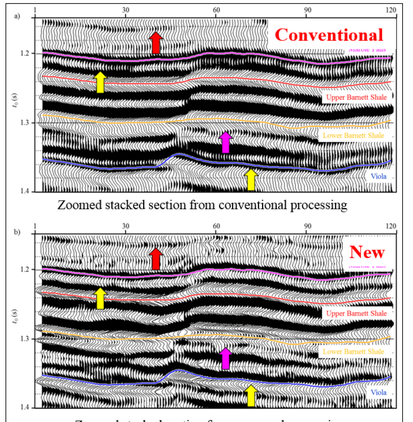

Figure 3. Stacked section using a) conventional and b) proposed processing workflow. Note the improved resolution in the section from new workflow.

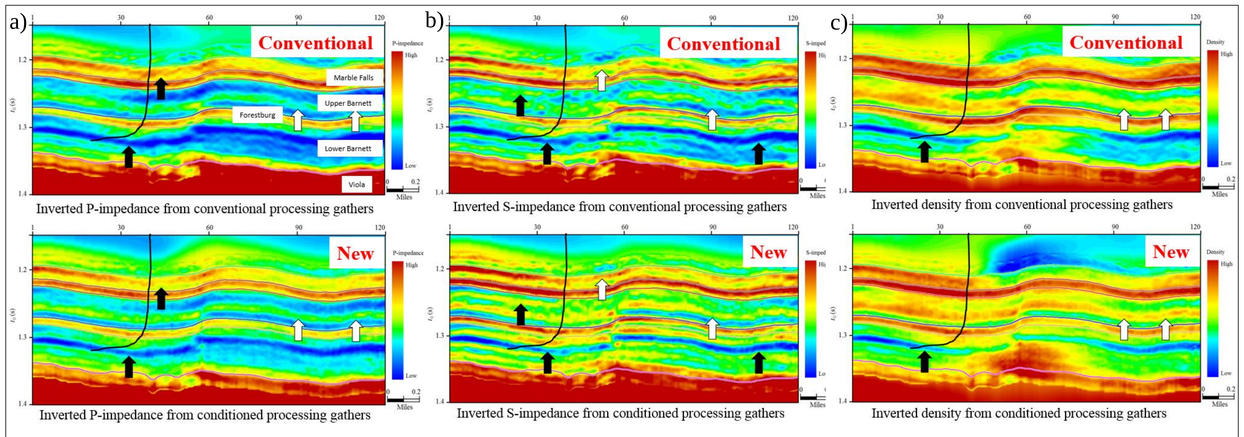

Figure 4. Prestack simultaneous inversion sections using the data from conventional and proposed workflow. a) P-impedance. b) S-impedance. c) Density. Note the improved resolution in the P and S impedances. The improvement in density is minimal because the maximum incident angle is about 36˚ for the target formations which is not enough for a reliable density estimation.

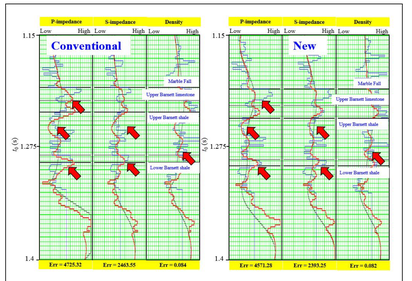

Figure 5. QC of inversion result on a well using data from a) conventional and b) proposed processing workflow. Note the improved inversion accuracy.

Conclusions

The proposed workflow maintains the frequency content of wavelets and rejects unwanted random noise through the small-intermediate- and large- angles. Thus more information is available for subsequent inversion, and the inverted result becomes more accurate. The prestack inverted results based on the new conditioned gathers not only show higher resolution but also exhibit a better match to the original well logs due to critical information contained in the far offset.

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