Unmask Imposter Seismic Artifacts and Unveil their True Identity with a Real-time Prestack Interpretation Workstation

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ABSTRACT

Geoscientists can greatly improve prospect evaluations by routinely analyzing prestack seismic data on a real-time, intelligently-integrated and live-linked interpretation workstation such as the EarthWorks Exploration System.

Imaging signal-enhanced, prestack gathers and range-limited stacks with real-time animation directly over interpreted seismic anomalies offers the geoscientist the uniquely powerful ability to see seismic anomalies decomposed into its basic prestack trace components. For the first time, geoscientists can directly distinguish the difference between seismic anomalies due to processing artifact and those that can be attributed to geology.

Although most prospect evaluations are still made solely on stacked data sets, stacking is a process that routinely degrades subsurface information. Most geoscientists realize and accept this unfortunate fact of stacking, however there never has been a practical and economical way to work with prestack data while simultaneously interpreting and mapping seismic data.

However, sophisticated 64-bit applications built for high-performance 64-bit microprocessors, such as those used in Compaq Alpha workstations, are now powerful enough to retrieve, store, process and visualize raw prestack data *in real-time*. Geoscientists using these tools have the ability to quickly look at seismic data in much more critical detail and jump a quantum level ahead in subsurface understanding.

Why we should look deeper into the origins of our stacked seismic data

It is rare for a seismic interpreter to analyze prestack seismic data, yet this data is the source of all the seismic information from which we derive our drilling conclusions. Our time structure, isochron and character maps are all derived from stacked data. If the prestack data is corrupt or poorly processed, our interpretations will suffer.

Seismic processors spend a great deal of time and energy ensuring the data is processed correctly using a myriad of processing parameters. Static corrections, velocity functions, mute patterns and geometry details must be correct in order to get the most out of your seismic data and to prevent creating seismic artifacts. However, most geoscientists realize that the same raw data given to different processors will often yield different results.

Seismic interpreters really have little information to assess the quality of the processing for any given anomaly. However, a quick look at the prestack data is a great quality control tool to establish confidence in our interpretation.

Stacking is simply averaging groups of traces that are designed and processed to measure a common depth point. Typically somewhere around 30 prestack traces are stacked to create each individual trace on a final seismic section. Since different sets of prestack traces can create

identical stacked output traces, we must look at the prestack data to ensure the stacked traces are not giving us false positive anomalies.

Amplitude Variation with Offset (AVO) analysis has been investigated and successful accounts published since 1984, however, most geoscientists do not routinely analyze their seismic data for AVO anomalies. We should be looking for AVO anomalies and using this powerful technique in our seismic interpretations on a routine basis.

Anisotropy is very rarely investigated and almost no processor takes anisotropy into account. Yet if you can detect anisotropy in your data set, it may signal key reservoir characteristics that can significantly affect drilling decisions and improve production rates.

It is time that we unmask the seismic expressions on stacked data sets and reveal their true nature. Understanding prestack seismic data is the key element to better understanding the geology.

How do we routinely visualize prestack data *without killing a forest!*

On a leading-edge 64-bit workstation application built specifically to handle huge prestack volumes, it is possible to intelligently-integrate prestack analysis during a normal seismic interpretation session. Today's high-performance 64-bit systems connected to high-capacity disk subsystems enable even the largest seismic projects to store, retrieve, process and visualize prestack data in real-time.

There are many different ways to view prestack data. Looking at raw NMO corrected and static corrected gathers are usually unproductive, because the signal-to-noise ratio is poor and it is difficult to identify key events. We use several real-time processing technologies to enhance the interpretation of prestack data.

Real-time Ostrander supergathers improve signal-to-noise ratios

Ostrander gathers is simply the partial stacking of ranges of offsets to improve signal-to-noise ratios. When built with real-time capabilities, the geoscientist can adjust controls and watch the Ostrander gathers animate and visualize the changing fold within each offset trace. Thus, with a real-time system such as EarthWorks, the user can stop at the appropriate offset bin size when the quality of the Ostrander gather is sufficiently high.

Additionally, geoscientists using EarthWorks can adjust a supergather control that computes Ostrander gathers for nearby CDP's and sums the appropriate offsets to create a supergather of improved quality at the expense of possibly smearing geology. Because this is a real-time operation, the user can adjust and watch the Ostrander supergathers animate until the quality is sufficiently high while also keeping an eye on the amount of geological smearing that may be occurring.

In EarthWorks, Ostrander supergathers are displayed as overlays on regular interpretable seismic data. Consequently the relationship between a seismic anomaly and its constituent prestack traces are *immediately* realized. Furthermore, the user can drag this window and watch the prestack traces animate to show in detail how a seismic anomaly is formed in the prestack domain.

Now geoscientists can distinguish the difference between seismic anomalies due to processing artifacts and those caused by geology with very little time and energy. AVO anomalies can also be detected and evaluated during the normal course of interpretation.

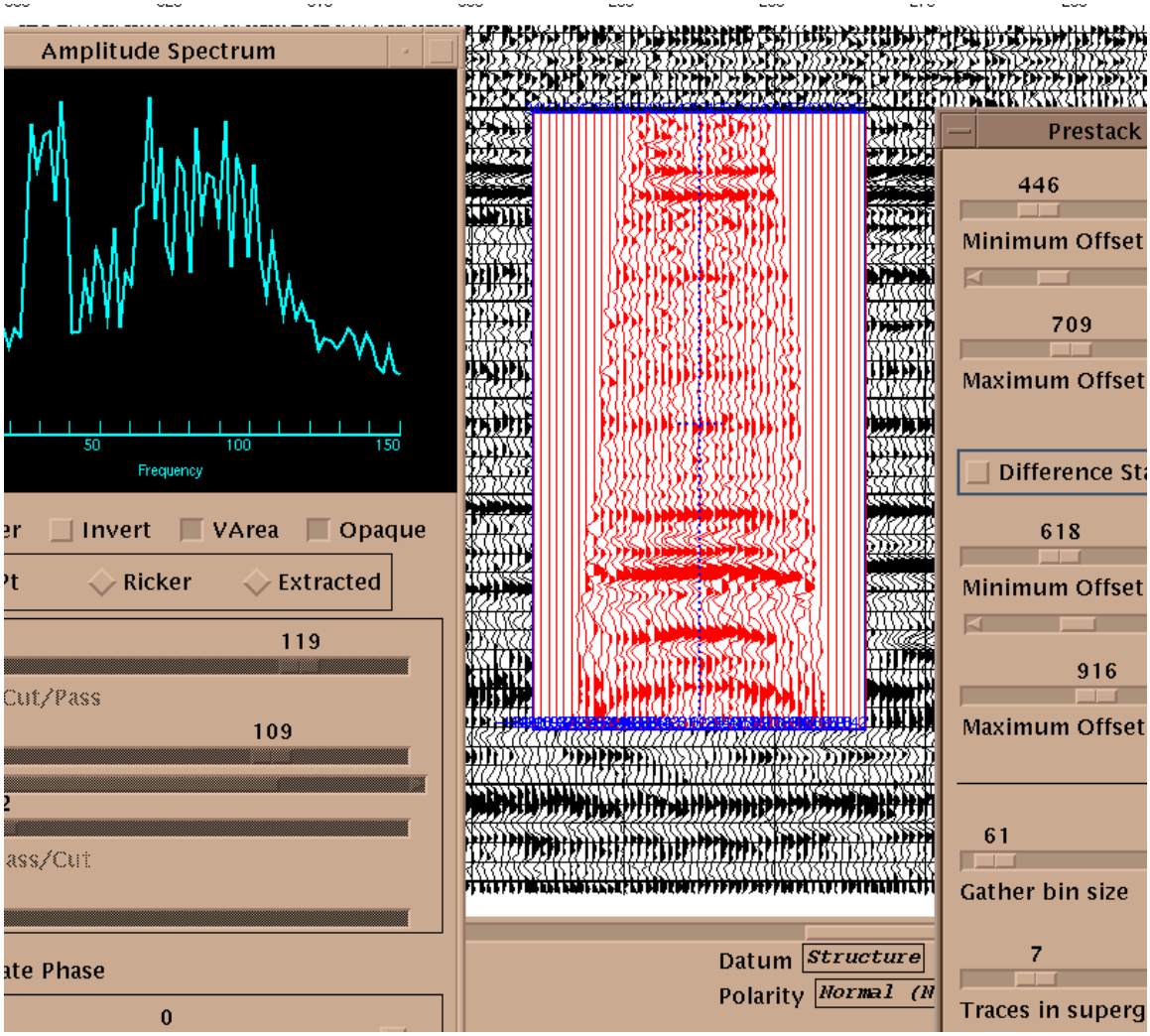

Figure 1: Ostrander supergathers are analyzed in an EarthWorks window. This is made by simply dragging out an analysis box on the stacked section shown in black and white VA traces in the background. The supergathers are built for the CDP specified by the vertical blue dashed line. Fold for each trace is reported at the top of the window and offset is reported at the bottom. In real-time, the user can modify the gather bin sizes and the number of CDP's used in the supergather. The Ostrander supergather will animate as the user changes parameters, continually computing the supergather to reflect the changes.

Range-limited stacks improves temporal resolution and visualizes AVO anomalies

Since EarthWorks stores and retrieves all prestack traces, it is free to stack all or only some of these traces to create a partial or range-limited stack. As with all EarthWorks tools, it builds range-limited stacks in real-time. Adjusting controls cause EarthWorks to animate the partial stack (again displayed overlaying and fully-integrated into your interpretation). Consequently, the geoscientist can continuously adjust offset ranges and watch the character of the partial stacks morph into new shapes.

One great reason to build range-limited stacks in real-time is that certain partial stacks can greatly boost the temporal resolution of your seismic data and give you a much clearer picture of the subsurface.

Additionally, AVO anomalies can be detected and analyzed by dragging an animated partial-difference stack over your seismic data. Like looking through a magnifying glass for AVO anomalies, real-time prestack visualization adds a refreshingly new dimension to the wiggle picking many of us have to endure.

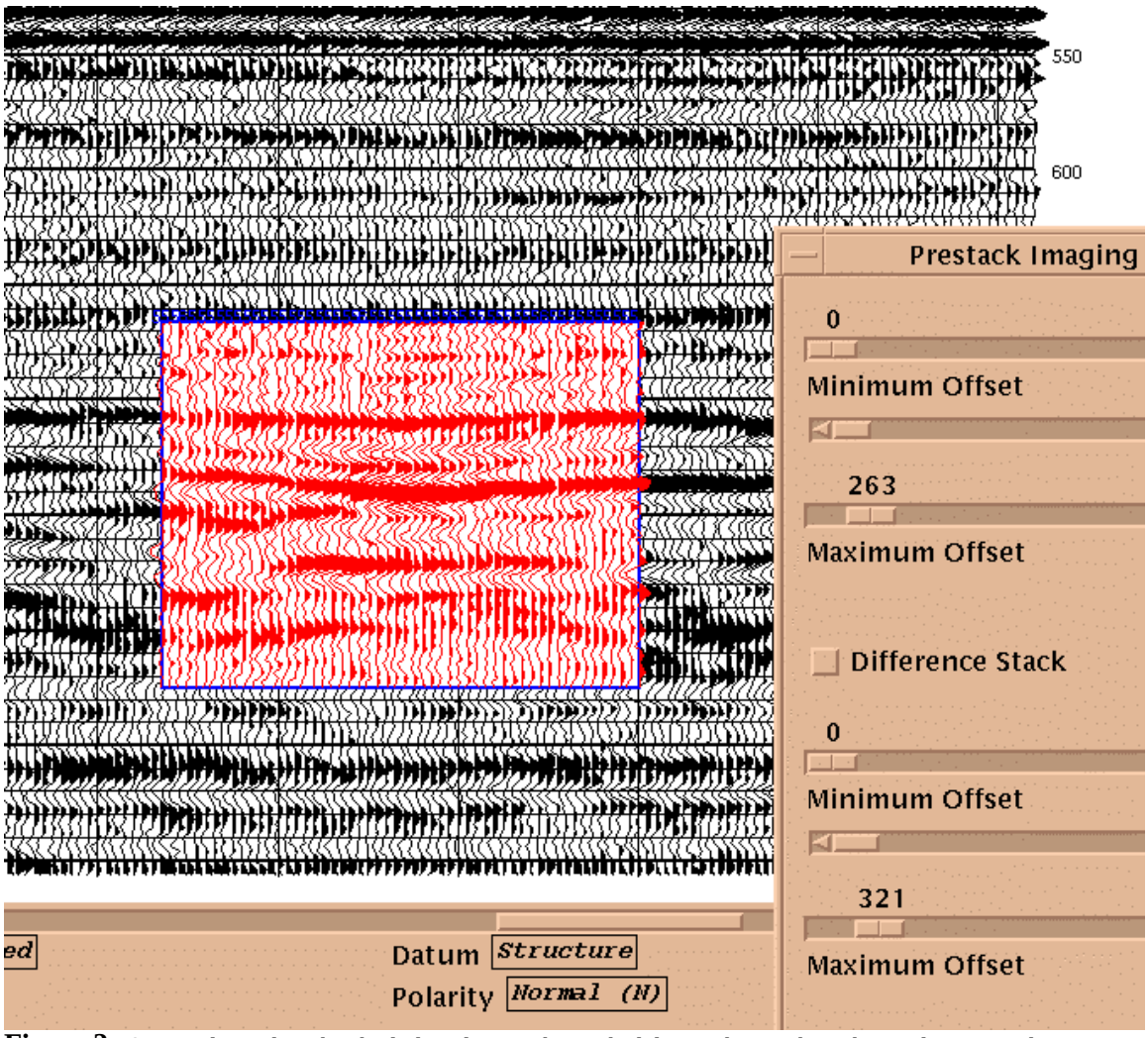

Figure 2: A range-limited stack is built directly over the stacked data in this EarthWorks window. In real-time, you can adjust the offset range to see near, mid and far offset stacks. In real-time, you can adjust from near to far offsets continuously while watching the range-limited stack results animate. Difference stacks may also be built in real-time, easily highlighting AVO anomalies and instantly allowing you to inspect anomalies found on stacked traces.

3D Azimuthal range-limited stacks uncovers anisotropic character

By limiting the partial stack by shot-receiver azimuth as well as offset distance, some truly interesting geological characteristics can be revealed. A geoscientist can request a range-limited stack on 3D seismic data and then animate the results of stacking a particular range of azimuths. By spinning this primary vector around, EarthWorks reveals the anisotropic nature of the data that may be due to the geology. This can help evaluate reservoir characteristics such as fracture orientations and aid in drilling and production decisions.

Jump up a quantum level and *routinely* visualize prestack data in real-time

In the past, stacking was necessary to improve signal-to-noise ratios in order to see weak events. However, improvements in geophone design, acquisition instrumentation and processing has significantly reduced the importance of stacking. Stacking is degrading useful information and blurring the clarity of our subsurface images.

The data transfer between processors and seismic interpreters has generally been stacked data but the hand-off point should be moved back up the processing stream to NMO corrected and static corrected CDP gathers.

High-performance 64-bit workstations with sophisticated real-time prestack software allow geoscientists to take the data in its prestack form. Analyzing prestack data on-the-fly and completely integrating this information into a normal interpretation workflow is a quantum step forward towards improving our exploration success rate and lowering our finding costs. Unmask those stacked traces and gaze into the truth of prestack data and never be fooled again by those seismic artifact imposters!

Acknowledgements

I would like to thank John Card and Dr Easton Wren for their friendship and continuing roles as mentors. I would also like to thank Norbert Bernoth and Jim Laing and the other processors at Apoterra Seismic Processing for their great support and their unique insight into seismic data processing and prestack analysis.

I would like to thank Compaq Canada for loaning us their highest-performing 64-bit Alpha workstations. Finally, I would like to thank the client's of Genetek Earth Research for it is from their comments that make us stretch EarthWorks to new levels of functionality and performance.

Author's Biography

Mark Sun is an exploration geophysicist, the developer of the EarthWorks Exploration System and founder and president of Genetek Earth Research. After 8 years as a seismic interpreter with Suncor in Calgary, he left exploration geophysics to build his dream workstation designed for geoscientists. Sun received his B.Sc. in Geophysics in 1981 from the University of British Columbia and has been writing software since he was a kid.