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Residual Moveout Analysis in a 3D dataset from Amplitude Variations with Offset

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Summary

The amplitude variations with offset (AVO) is a very useful tool which compliments the conventional stacked section with added information concerning the converted waves (e.g. Ostrander 1984, Shuey 1985, Hilterman 1990). In 2001, H.W.Swan has shown that the sensitivity of amplitude variations with offset (AVO) to Normal moveout (NMO) velocity errors can be exploited to obtain more accurate velocities from a fully automated procedure, which significantly more sensitive to velocity variations than the semblance coefficient (as defined by Neideel and Taner in 1971).

In this paper, we have discussed a case study to find out the residual moveout corrections on time migrated gathers from amplitude variations with offset in a large volume of 3D land dataset in Cauvery Basin using Swan's technique. This procedure uses AVO techniques in order to automatically perform detailed residual moveout analysis. Residual moveout operates as conventional normal moveout (2nd order) analysis as well as 4th order analysis to correct time migrated gathers at large offsets which exhibit 4th order moveout. This procedure enables to generate residual moveout or residual velocity volumes and thus can update RMS velocity volume & moveout corrected gathers (flat gathers in time migrated domain). In this paper, we have also discussed about the benefits and accuracy of this procedure over the conventional technique of picking residual moveout corrections through residual velocity analysis semblance plot using time migrated gathers as input & RMS velocity volume (migration velocity) as the background velocity.

Introduction

The pre-requisite for 3D Pre stack time migration (Kirchoff PSTM) for land data requires a conditioned decon cdp gather with applied residual statics and a near perfect RMS velocity model. The initial RMS velocity volume is usually obtained from DIX conversion of the of the stacking velocity in time domain for running of target oriented time migration (TOTM) in fixed line interval (inline or crossline) . The product of TOTM is time migrated gathers (CRP gathers) and a PSTM stack. On these time migrated gathers , the actual RMS velocity is generally picked inverting the NMO on the time migrated gathers from the semblance plot and thus a near perfect RMS velocity volume is obtained after proper QC of the flatness of the TM gathers to run the final PSTM for full volume. After PSTM, again the flatness of the time migrated gathers are to be checked in fixed inline or cross line interval and it is seen that there is always a scope for residual velocity or residual moveout correction for fine tuning of the RMS velocity model as such.

The procedure describe here provides an automatic calculation of residual moveout with respect to time migrated gathers after fixing parameters in the interactive mode on selected gathers and proper QC for flatness of gathers in different reflector level and thus a residual moveout volume can be prepared for the whole 3D volume. With the help of this residual moveout volume the earlier time migrated gathers can be corrected (PSTM flat gathers) and a final PSTM stack volume may be obtained.

Study Area

The area is situated to the South east of the Kovilkalappal field. It is bounded in the east and south by a NELP block operated by Niko Resources and in the North by Tiruttaraipundi high. Area covers a small oil field viz. Tulsapattinam. This campaign was acquired with the prime objective of delineation of Tulsapattinam pay (post rift Nannilam formation). A total of 9 exploratory wells have been drilled in and around the area. However one well A-1 falling in area 'A' is the lone hydrocarbon bearing well in the area. The location map of the area is depicted in Fig-1.



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Figure -1: Location Map of the area

Reasons for 3D survey

The proposed area is covered by earlier by 3D seismic survey in the year 1998-99 with (20m X 40m) Bin size, with the prime objective of delineation of Tulsapattinam pay (shallower play). But the quality of 3D seismic data is not sufficient to resolve deeper play or map the envisaged Stratigraphic features. Additionally, the frequency content in the available data is also low, as a result various seismic attribute attempted with Tulsapattinam 3D did not produce realistic output. As a result the high potential area remained under explored all these years. Thus this part of area is proposed for repeat acquisition with (20mX20m) Bin size.

Theoretical Background

The amplitude variations with offset (AVO) is a very useful tool which compliments the conventional stacked section with added information concerning the converted waves (e.g. Ostrander 1984, Shuey 1985, Hilterman 1990). In 2001, H.W.Swan has shown that the sensitivity of amplitude variations with offset (AVO) to Normal moveout (NMO) velocity errors can be exploited to obtain more accurate velocities from a fully automated procedure, which significantly more sensitive to velocity variations than the semblance coefficient (as defined by Neideel and Taner in 1971). This procedure uses AVO techniques in order to automatically perform detailed residual moveout analysis. Residual moveout operates as conventional normal

moveout (2nd order) analysis as well as 4th order analysis to correct time migrated gathers at large offsets which exhibit 4th order moveout. This procedure enables to generate residual moveout or velocity volumes and thus can update RMS velocity volume & moveout corrected gathers (flat gathers in time migrated domain).

Auto-picking is computationally more efficient than it would be with semblance because only one correlation trace is calculated for each iteration, instead of one for every trial velocity. This efficiency makes velocity picking of every gather in a 3D survey feasible.

This method consists of the following steps, AVO analysis, removal of NMO stretch errors, calculation of joint statistics between the analytic intercepts & gradients and picking an NMO velocity to null this indicator.

Methodology & Procedure

Input Data

The input data for this procedure is time migrated gathers. These gathers have been obtained from PSTM (Kirchhoff). The conditioned decon gather & a RMS velocity model were the pre-requisite for first run of PSTM. There after RMS velocity was picked on time migrated gathers inverting NMO and a near perfect RMS velocity model was prepared. After that, PSTM for the full 3D volume was performed with this conditioned decon gather & RMS velocity. Fig-2 below illustrates the relationship for data with no AVO, but with a small error in stacking velocity. As per Swan's theory, a small stacking velocity error aligns data curve $t(\theta)$ and produces time misalignments (t) and amplitude variations (S). The time misalignment t is a function of the shot-receiver offset x , true rms velocity V , zero offset travelttime t_0 , and velocity error ΔV .



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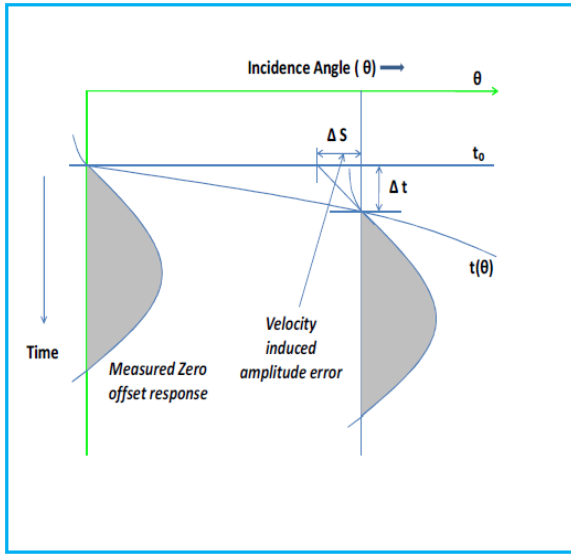


Figure-2

Processing Algorithm

This procedure uses AVO techniques in order to automatically perform detailed residual moveout analysis. Automatic residual moveout operates as conventional normal moveout (2nd order) and as 4th order correction to correct gathers at large offsets which exhibit 4th order moveout. The basic workflow is mentioned in Fig-3.

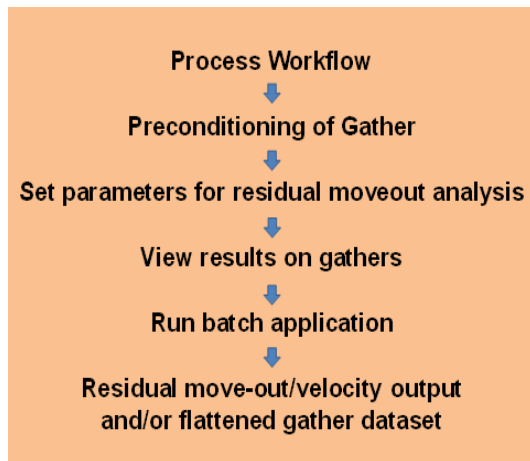


Figure-3

The input time migrated gathers requires some pre conditioning before AVO analysis and calculation for residual moveout in the gather if any. Fig-4 shows the input

pstm gather in TM (time migrated) domain before and after pre conditioning, a calculated residual moveout section in one inline from the 3D volume and the residual section after smoothing. In this case only 2nd order nmo correction is applied. In this case the input gather is corrected with 2nd order correction only. Fig-5 shows the gathers after 4th order correction, which shows the flatness of the gathers in the far offset also.

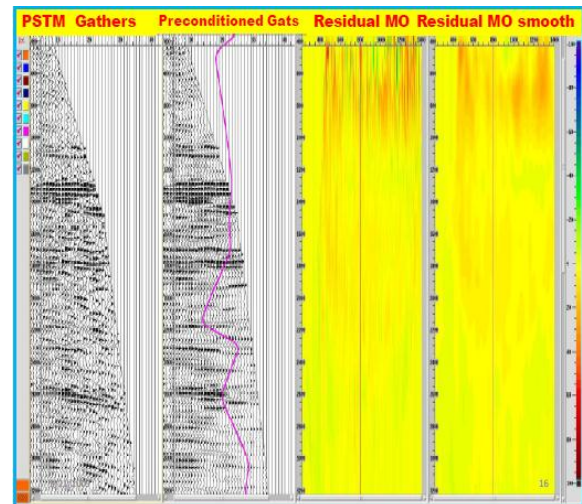


Figure-4

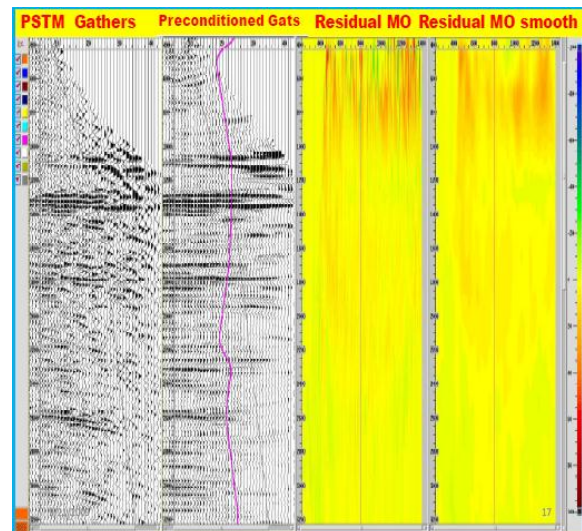


Figure-5

Fig-6 shows the input gathers and the output flat pstm gathers after this process.



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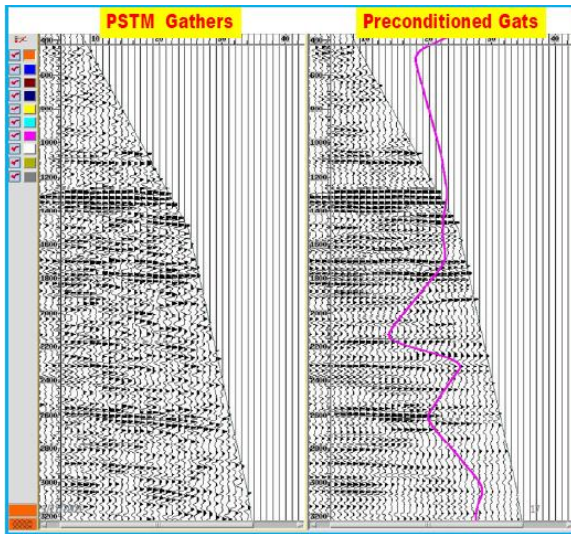


Figure- 6

Fig-7 shows the second & fourth order residual move out curve. The scale of residual velocity or residual moveout is described in the diagram. The point towards right shows the 100% positive residual moveout whereas the leftside is negative moveout. The nature of the curve, describe the accuracy of actual RMS velocity pick from the time migrated gathers.

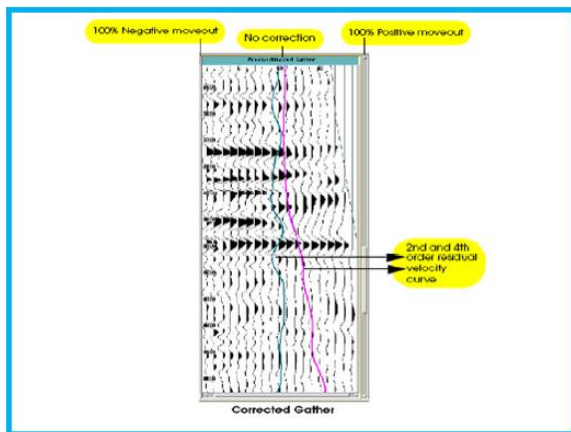


Figure- 7

The figure-8 shows the flatness of the input pstm gathers after 10 iterations & 20 iterations respectively, thus customizing the parameters.

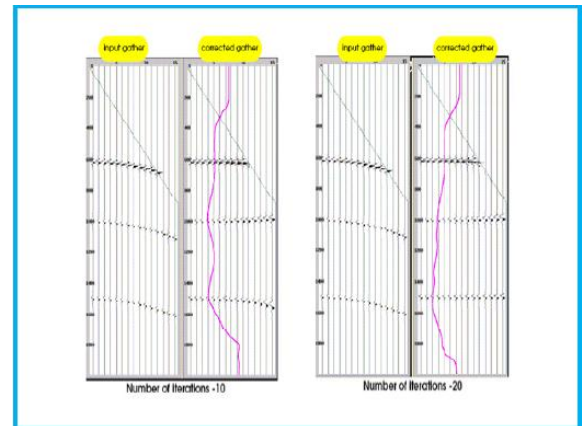


Figure-8

Whereas in Fig-9, the iterations are 30 & 40 respectively. Sometimes more iterations are required for flatness of the gathers and more iterations require more computational time. Therefore the optimum iterations are to be chosen keeping in view the computational time & quality of the output gather & stack.

The same exercise has been done manually to find out the residual moveout correction from residual velocity analysis semblance plot.

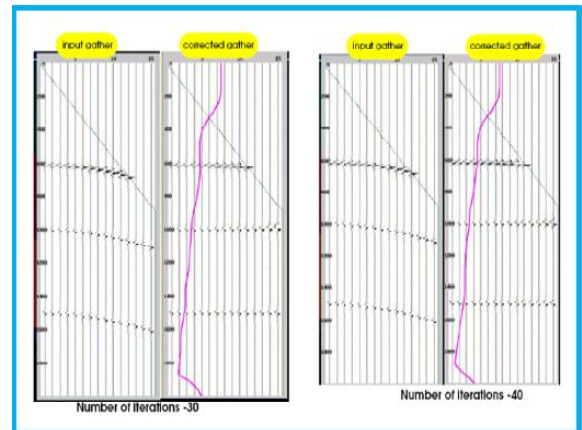


Figure- 9

The fig-10 shows the residual velocity analysis or residual moveout analysis in the manual hand picked mode. The left side in the velocity panel is the time migrated section, in the middle residual time migrated move-out and in the right hand side of the semblance shows the pstm flat gathers after application of residual moveout analysis and application.

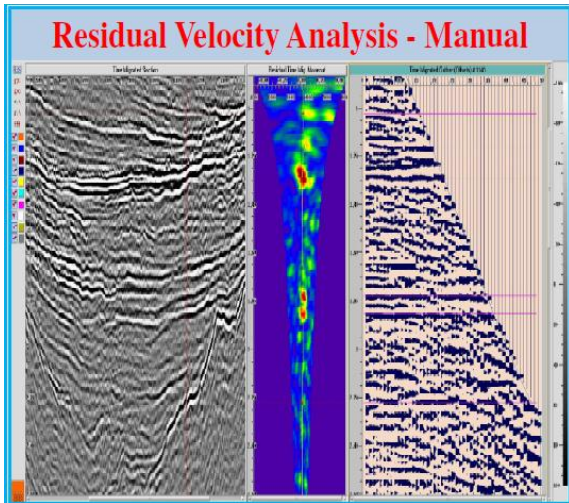


Figure- 10

The fig-11 shows the residual moveout analysis of the same time migrated gather from amplitude variation with technique.

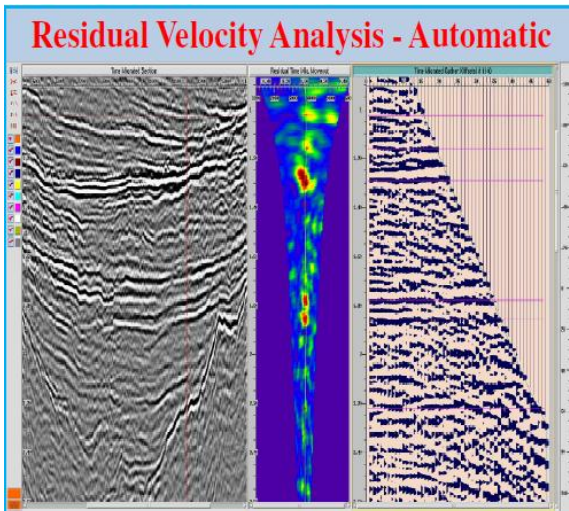


Figure -11

Fig-12 shows the residual move out analysis from hand picked of the same gather after zooming it.

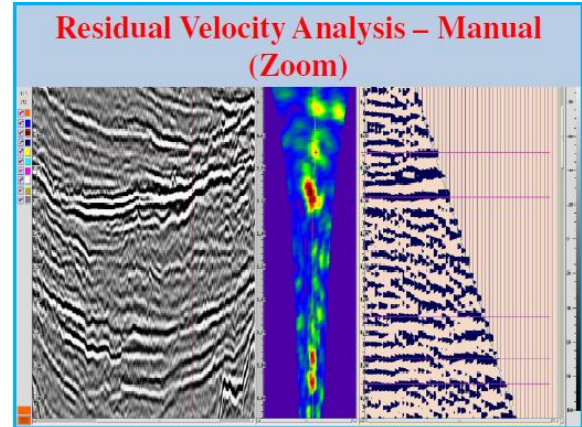


Figure – 12

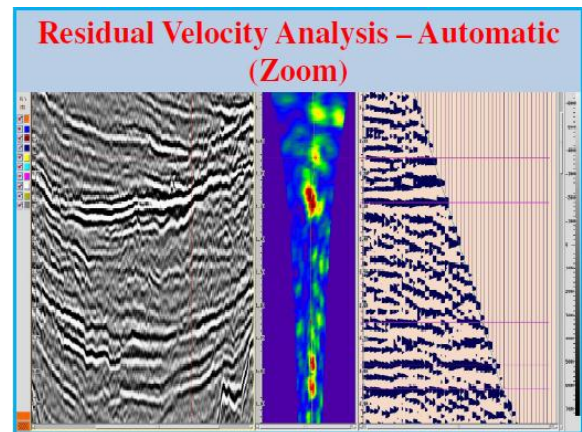


Figure – 13

Fig-13 shows the residual move out analysis from amplitude variations with offset of the same gather after zooming it. Fig-12 & 13 shows the manual residual moveout correction and residual moveout correction from AVO studies with this technique are almost yields similar results.

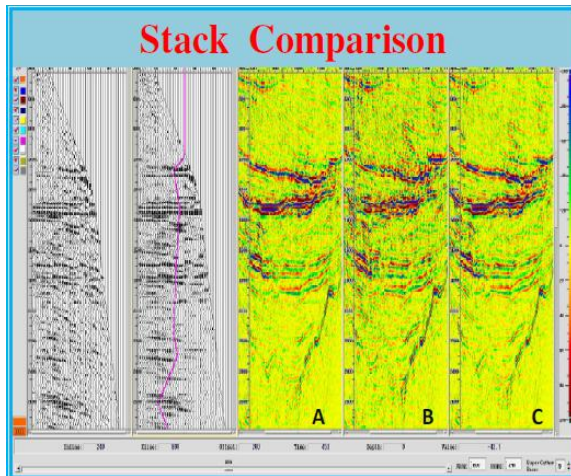


Figure – 14

Fig-14 above shows a panel where the two time migrated gathers are before and after pre conditioning with this technique and the stack panel shows stacks before application of residual move out (A), after application of residual move out which was hand picked (B), and the third one (C) is after application of residual move out which was calculated from amplitude variations with offset. The results of hand picked residuals and residual picked or computed from this technique is yielding same results.

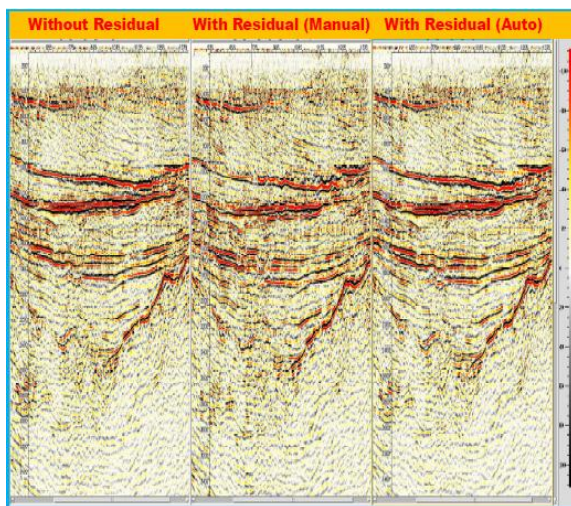


Figure – 15

The above fig-15 shows the stack comparison before application of RMO, after application of RMO (hand picked) and application of RMO from avo technique.

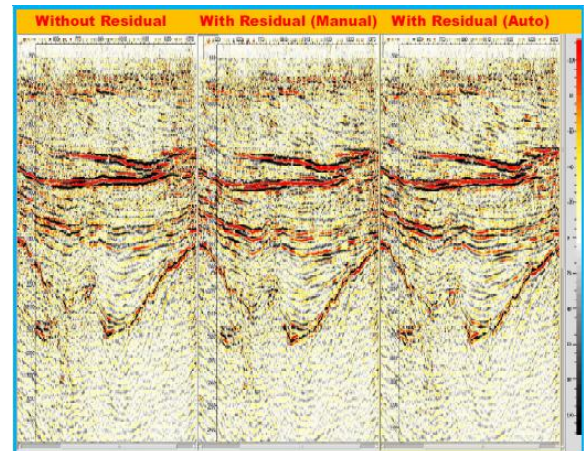


Figure – 16

Fig-16 shows the comparisons from another inline section from the same 3D dataset.

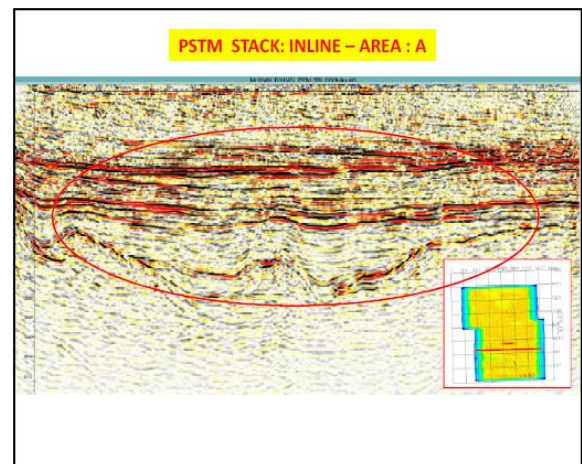


Figure – 17

Fig-17 shows a full inline from the 3D dataset after computations and application of residual moveout correction from AVO studies.

Conclusions

The actual RMS velocity is generally picked manually from the semblance plot, inverting the NMO on the time migrated gathers derived from the first pass pre-stack migration. The accuracy of RMS velocity pick depends upon the flatness of the time migrated gathers. When picking the RMS velocities for a large volume of 3D



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dataset with a very close grid velocity analysis say, (400mX400m), there is always a chance of left-out residual move-out correction in the dataset. It is legitimate to check the residual moveout correction in the time migrated gather before final stack of the data.

In this paper, the residual move-out corrections have done both manually and using Swan's technique. This procedure uses AVO techniques in order to automatically perform detailed residual move-out analysis. At first, in the interactive mode, the parameters has to be designed, then the job can be performed through batch mode automatically, which reduces the manual labour. However, this process works better when signal to noise ratio in dataset is good.

Auto-picking is computationally more efficient than it would be with semblance because only one correlation trace is calculated for each iteration, instead of one for every trial velocity. Moreover in turn it reduces the computational time. This efficiency makes velocity picking of every gather in a 3D survey feasible.

This procedure enables to generate residual move-out or velocity volumes and thus can update RMS velocity volume & move-out corrected gathers (flat gathers in time migrated domain).

The processed section reveals the sub-surface image better than earlier vintages and brings out an improvement in the seismic section compared to the earlier processed section.

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