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Improved Subsurface Imaging through Kirchoff Prestack Time Migration: A Case Study from Mehsana Block of Cambay Basin

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Summary

Attempts to reprocess vintage 2D seismic data is often a tough task particularly when the seismic data is contained in different line segments shot with varying acquisition geometry. The present paper deals with a case study wherein old seismic data of three different campaigns were reprocessed with dual objective to better delineate the basin margin fault in the Mehsana Block and to improve the mappability of various sequences viz. Kalol, OCS and Olpad in the west of Mehsana Horst whereas of Kalol, Kadi, Linch and OCS sequences in the east of Mehsana Horst of Cambay Basin. Prestack merging of 2D line segments with non-uniform geometry was done by trace header manipulation of picket numbers. The missing trace interpolation was achieved by Kirchoff Prestack Time Migration, which had the dual role of Pre Stack Trace interpolation and Migration. The quality of subsurface imaging brought out by the reprocessed sections has been greatly enhanced by prestack merging and PSTM for better seismic resolution for fault plane identification.

Introduction and study area

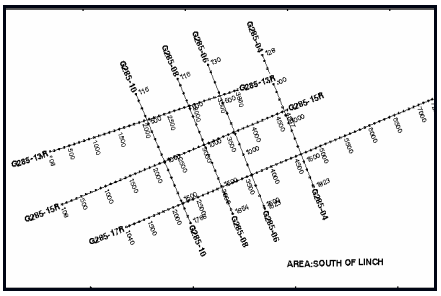
The objective of the study was to bring out precisely the framework of basin margin fault in the eastern and western direction in the Mehsana Horst Block area of Cambay Basin. The other objective was to map Kalol, OCS & Olpad sequences in the west of Mehsana Horst within a time window of 900-3500ms and to map Kalol, Kadi, Linch & OCS sequences in the east of Mehsana Horst within a time window of 900-3000ms.

During this project, 2D seismic lines of three different campaigns (a total of 890 GLK of seismic data) pertaining to area south of Linch, south of Patan, North of Mehsana of Cambay Basin (Figure 1) under three seismic campaigns were taken up reprocessing. The details of the seismic lines are given in Table-1.

Seismic Lines	Segments	Seismic Lines	Segments
IN.No.1-L1	A, B, C	IN.No3-L1	A, B, C
IN.No1-L2	A, B, C	IN.No3-L2	A, B, C,D,
IN.No.1-L3	A, B, C, D		
IN.No.2-L1	A, B, C	IN.No.3-L3	A, B, C, D, E
IN.No2-L2		IN.No.3-L4	A, B, C, D, E

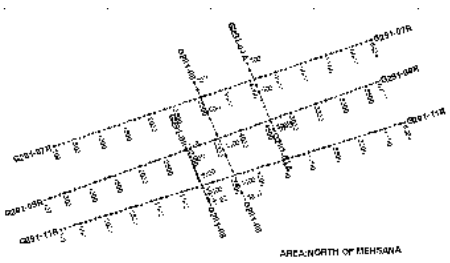
Brief Geology

Cambay Basin is an intracratonic basin ,which came into existance by the development of tensional faults along the margins.Subsquently due to various environment conditions Olpad formation , Cambay shale, Kadi formation, Kalol formation, Trapur formation and Jambusar formation were developed. Mehsana Horst is one of the prominent structural features in this area. Oil fields present in the area are Santhal, Balol, Becharaji, Jotana and Sobhasan. Kalol and Kadi are main oil produceing formations in the area.



a) IN.No.1 (South of Linch)

b) IN.No2 (South of Patan)



c)IN.No.3 (North of Mehsana)

Figure 1 (a, b, & c) Location map of the area and alignment of 2D lines.

Methodology

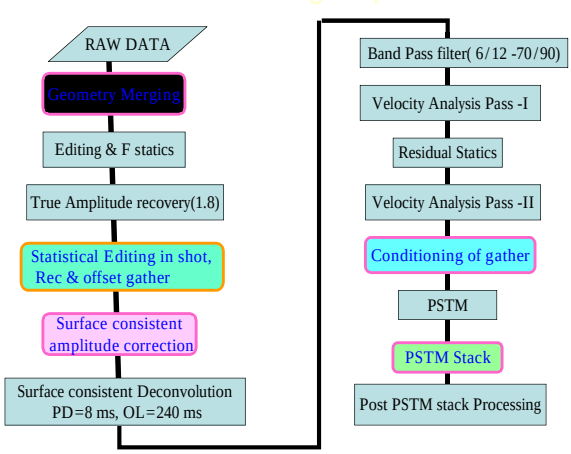
The workflow followed during the project was as follows:

i) Prestack merging of the individual line segments shot with varying acquisition geometries into a single line.

ii) Prestack imaging of data for better resolution.

Post PSTM processing

Processing Sequence



Prestack Merging

2D lines were shot in different segments with different acquisition geometry, different shot interval, group interval, receiver line and hence different CDP interval. Multiple segments of seismic lines IN.No1-L1, IN.No1-L2 & IN.No2-L1(3 segments each), IN.No1-L3 & IN.No.3-L2 (4 segments each) and IN.No.3-L3 & IN.No3-L4 (5 segments each) (Table-1) were first taken up for redesignating the SP's and CDP's to merge them into a continuous line to produce regional seismic lines with uniform trace spacing(Figure 2)

Renumbering the pickets uniquely, honouring their locations within and across the line segments was equivalent to restaking the total line with new picket numbers with interval of 10m, which is the highest common factor of 20m, 30m and 40m. This procedure ensured continuous CDP numbering, though many of them were devoid of traces. The task of generating the missing traces was left to Kirchoff PreStack Time Migration and CDPs were finally generated at interval of 5 m.

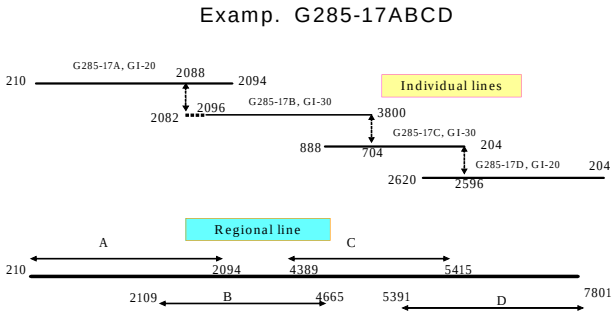


Figure 2 Continuous renumbered pickets across the segments Processing sequence of merged lines

Conventional processing flows like geometry merging and surface consistent applications using original field geometry was applied. The next step was to go for trace header manipulation to renumber the shot points and receiver points to effect the new geometry. After this, conditioned CDP gathers (Fig. 3) were subjected to PSTM routine where the missing CDPs were interpolated with live traces on output. Finally, PSTM stack was carried out.

The PSTM methodology included the following:

1) Stacking velocity analysis at 250m intervals.
2) Conversion of stacking velocity to RMS velocity.
3) First Pass Migration.
4) Picking up of RMS velocity on PSTM gathers at 250m intervals.
5) Creation of RMS velocity section.
6) Second Pass Migration. (PSTM).
7) Picking of residual move out.
8) Generation of Flat gathers.
9) Mute and Stack.
10) Post Stack processing (BP filter, RNA and scaling).

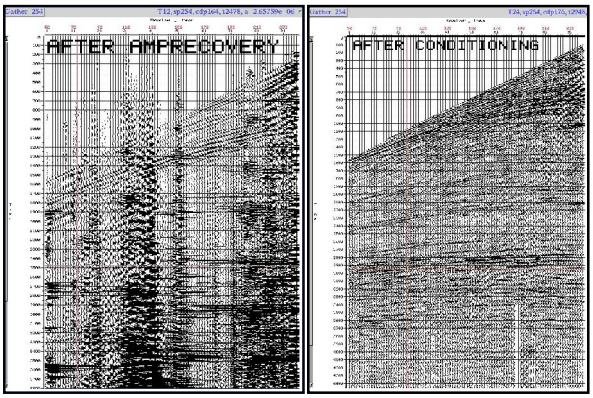
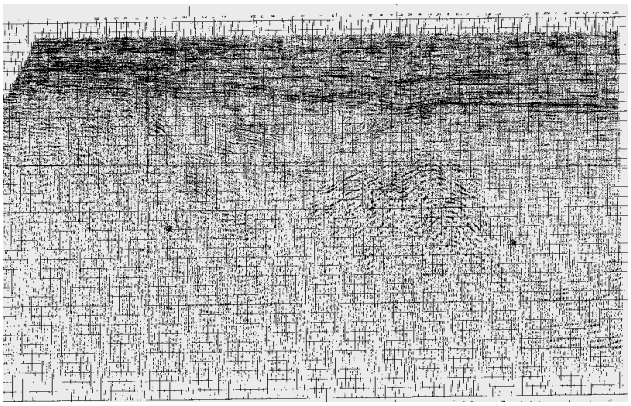


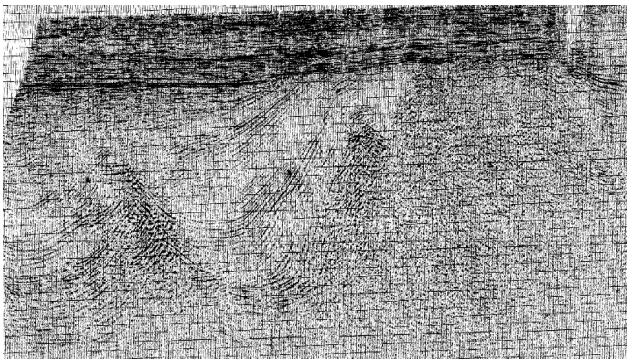
Figure 3 Shot gather, a) Before conditioning; b) After conditioning.

Comparison of processed data

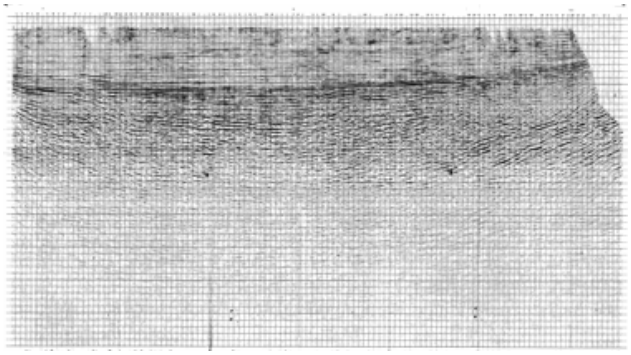
Figure 4 (a to d) show the previously processed data of different line segments, which can be compared with corresponding segments after reprocessing (normal stack) during this study (Figure 5: a to d).



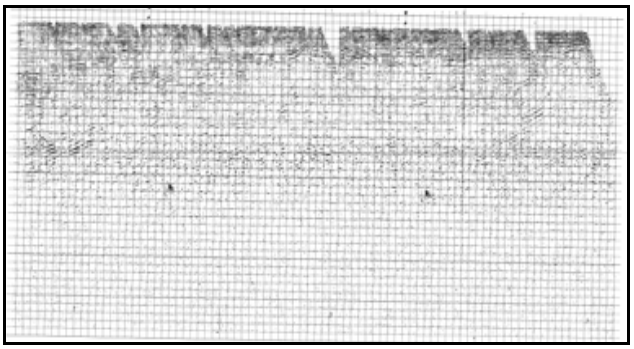
Segment A (IN.No3-L2A)



Segment B (IN.No3-L2B)

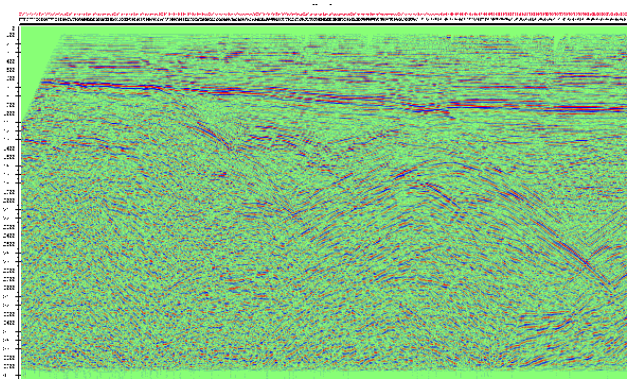


Segment C (IN.No3-L2C)

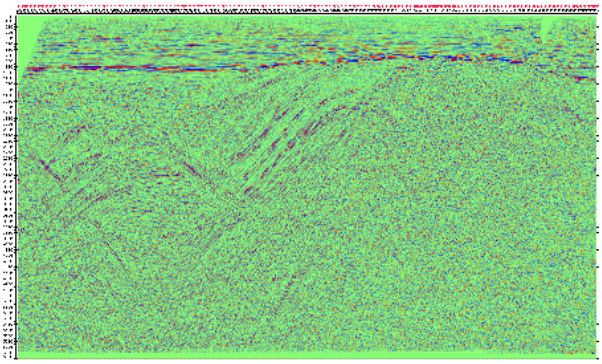


Segment D (IN.No3-L2D)

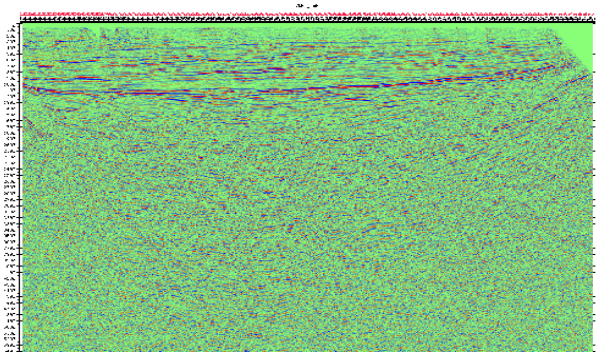
Figure 4 Previously processed data IN.No3-L2, Segments A,B,C &D.



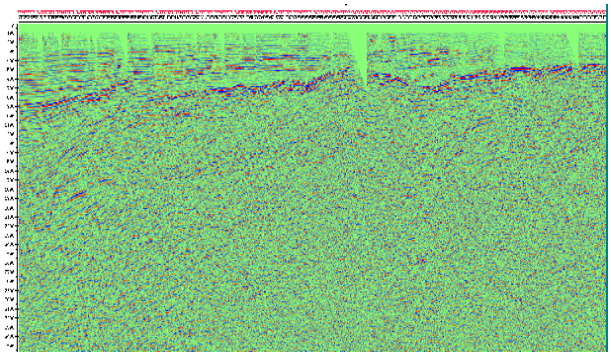
Segment A (IN.No3-L2A)



Segment B (IN.No3-L2B)



Segment C (IN.No3-L2C)



Segment D (IN.No3-L2D)

Fig. 5 Reprocessed data IN.No3-L2Segments A B C & D

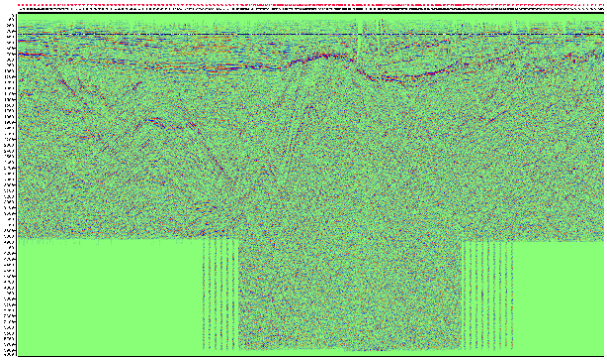


Figure 6 Combined Stack, IN.No3-L2

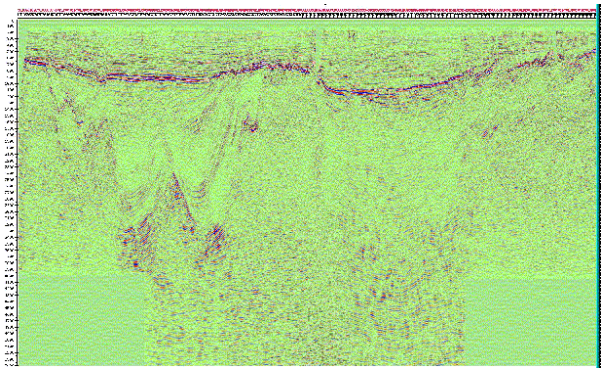


Figure 7 PSTM Stack, IN.No3-L2

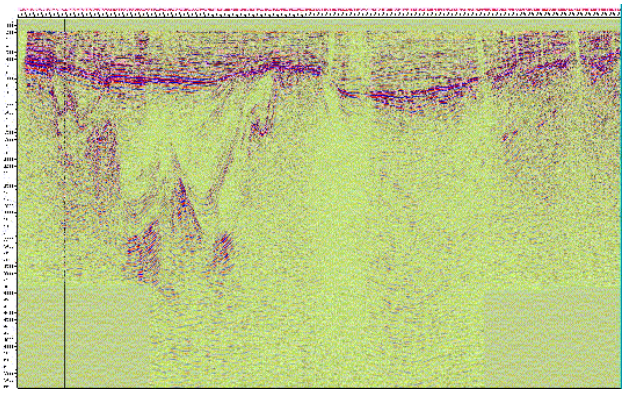


Figure 8 PSTM Stack (FX), IN.No3-L2

Figure 6 is the combined stack section of the entire line IN.No3-L2 and the next figure 7 shows the PSTM Stack of the same line. Considerable improvement in seismic resolution and continuity can be seen in the PSTM Stack. Figure 8 shows the PSTM Stack after carrying out the post processing. Figures 9 and 10 show the similarly processed final PSTM Stack (FX) sections of seismic lines IN.No.2-L2 & IN.No.3-L4.

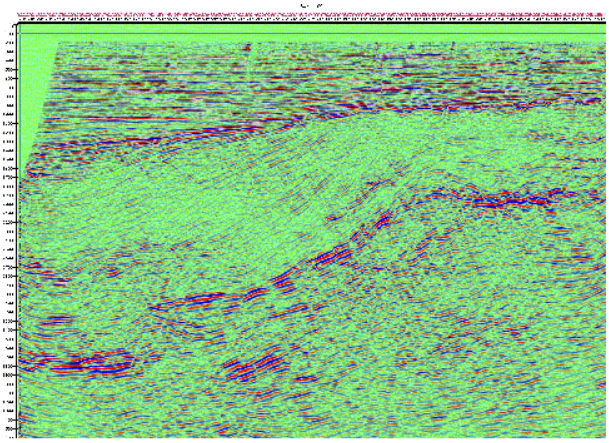


Figure 9 PSTM Stack (FX) IN.No2-L2

During the study, several important observations have been made with regard to value addition in the final processed sections. Advantages of pre-stack merging of various line segments are:

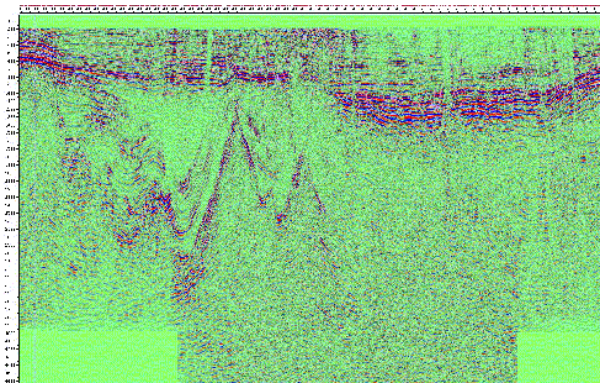


Figure 10 PSTM Stack (FX) IN.No3-L4

Value addition

- Merged PSTM of regional lines have brought out a clear picture of the fault planes.
- Better fault delineation.
- Improved mappability of various segments upto 3500ms.
- Seamless sections for interpretation
- No foldage tapering between the segments.
- Full aperture for PSTM.
- Reliable strati-graphic model from regional lines.

Conclusions

Pre-stack merging of 2D line segments with non-uniform geometry could be achieved by trace header manipulation of picket numbers. The missing trace interpolation was achieved by Kirchoff PSTM, which had the dual role of Pre Stack Trace interpolation and Migration. The processed sections brought out various regional strati-structural features with better clarity, compared to the earlier sections, which were available in pieces with poorly processed imaging.

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