Attenuation of Acquisition Footprint in 3D Land Data - A Case Study

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Summary

The linear spatial grid pattern seen on 3D seismic time slices is known as acquisition footprint and it has a dominant effect on pre-stack gathers. An attempt was made on field 3D seismic data pertaining to Cauvery Basin, India to remove the acquisition footprints from pre-stack gathers and subsequent time slices by weighted DMO and by wave number domain filtering respectively.

Introduction

The lateral variations in amplitude caused by variations in spatial distribution of traces due to the surface geometry used for data acquisition result in acquisition footprints on 3D seismic data and is more dominant in pre-stack gathers and shallower time slices. Ideally, a 3D survey is acquired on a 4-D grid (x, y, h, Δ) viz. midpoint, offset and azimuth. However, because of constraints, this space is often irregularly sampled. The outcome of this is the acquisition footprints that can be seen on pre-stack gathers and shallower time slices. The effect is worse when applying multi channel processing algorithms such as 3-D dip move out or 3-D pre-stack migration, as DMO is very sensitive to changes in both the azimuth and offset distributions.

Theoretical background

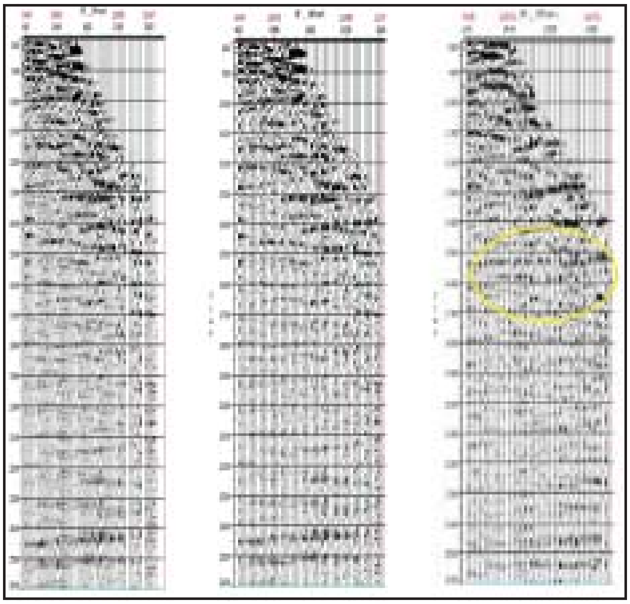
The present day acquisition geometries are periodic. The form of periodicity depends on source and receiver line direction and subsurface sampling. This causes periodic noises on the shallow time slices because coherent noises are differentially attenuated by each offset distribution. (Robert Soubras, 2002). The remnant of the periodic noises could also be called as acquisition footprints. DMO and PSTM are both spatial convolution procedures in which the signal is built by constructive interference at the envelope of overlapping operators and by destructive interference elsewhere. When the input space is irregularly sampled, the reconstructed amplitude is inexact and the destructive interference is imperfect, thus introducing noise into the data (Anat Canning et al., 1996). This link between true amplitude reconstruction and acquisition geometry is the cause for distortions observed in 3-D seismic data sets that were processed by applying DMO and PSTM. Artifacts are severe on unstacked data, which may mislead the processor with distorted velocity analysis. Incorporating a weighting scheme of DMO associated with respect to its neighbors helps in minimizing the artifacts caused by minor irregularities in acquisition geometry. (Anat Canning et al., 1998).

Other processes get influenced by footprints are residual NMO caused with incorrect velocities, systematic errors in computed offsets or amplitude variations caused by inadequate 3D DMO formulation, 3D prestack migration, signal enhancement based on Fxy random noise attenuation and coherency filtering. (Moldoveanu et al., 1999). Interpolation or extrapolation on input data volumes to get over the sparseness before applying multi channel processes can be a possible solution. Wave number domain filtering has also got useful applications here (Gulunay, 1999). The truncated singular volume decomposition (TSVD) technique applied in a cascade manner in the time slice domain suppresses both acquisition footprints and random noise while preserving the data character (Muhammad S. Al-Bannagi et al., 2005).

Noise attenuation by Weighted DMO – Field example

The pre-stack data was subjected to 3D dip move out correction with weighting considered. Pre-stack gathers selected to apply further processing are shown in Fig.(1-a) to Fig.(1-d).

The absolute amplitudes shown in Fig.(1-d) for time window of 1200 to 1350 ms show the increase in amplitudes with higher offsets after weighted dip move out correction whereas it appears to go unnoticed with simple dip move out correction. This in turn can lead the interpreter into uncertainties.



Fig(1-a): NMO corrected bin gather used as input; Fig(1-b): NMO corrected bin gather after DMO; and Fig(1-c): NMO corrected bin gather after WDMO.

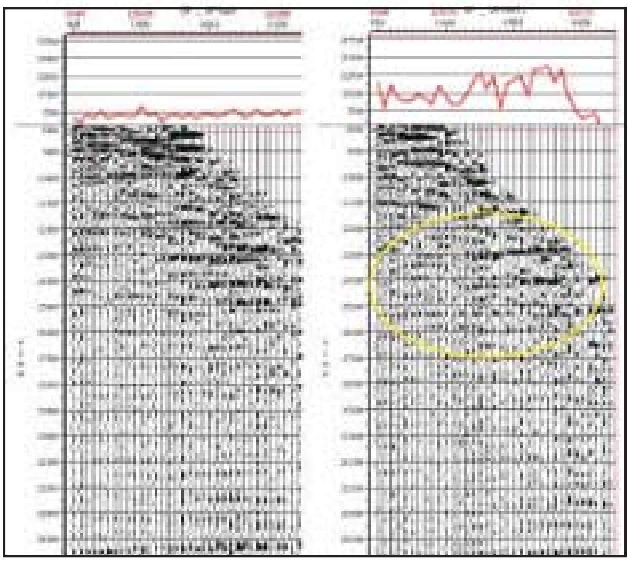


Fig.(1-d): NMO corrected bin gathers with DMO and weighted DMO.

Field example

The given post-stack 3D volume is sliced through every sample and typical slices are examined in the f-k domain for the linear noise patterns exhibited corresponding to the footprint lineations.

A very narrow f-k filter is designed at the level where the footprint is more pronounced. The sampled slices are f-k filtered to eliminate the linear patterns in one direction

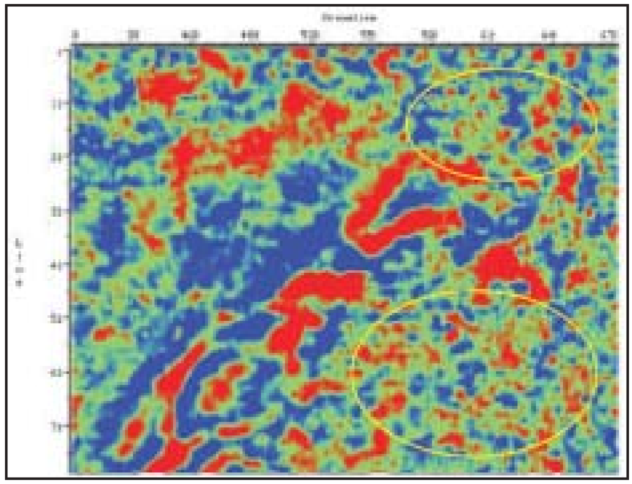


Fig.(2-a): Time slice before footprint removal.

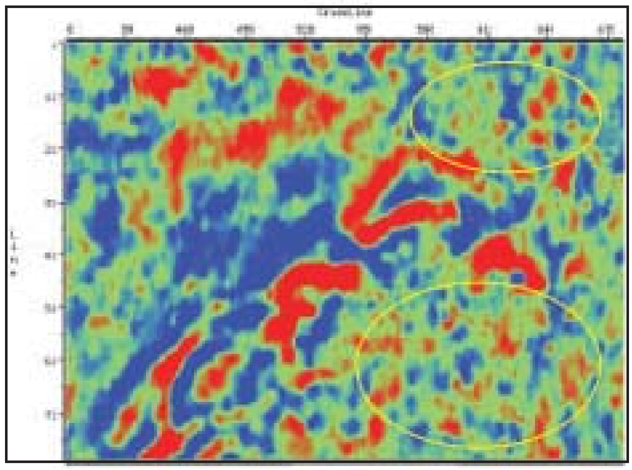


Fig.(2-b): Same time slice after footprint removal by f-k filtering.

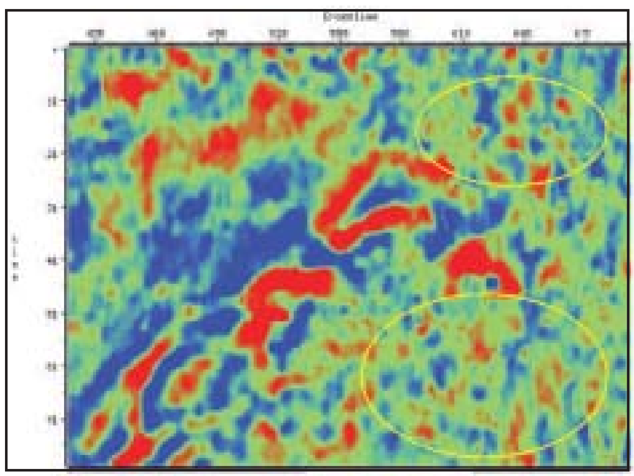


Fig.(2-c): Same time slice after footprint removal by Alpha trim filtering.

first and then in the orthogonal direction. The filtered individual slices are then combined into a composite seismic volume. (Satinder Chopra et al., 2000). In Alpha trim filtering, for each sample within the time slice the output is constructed by taking mean of the traces contained over a sliding window on the input sample. The outlying samples outside the window are rejected.

After removal of acquisition footprints, the seismic volume is clear of any lineation whatsoever, representing a significant improvement in data quality that could lead to more confident interpretation. While applying f-k filtering, ample care was taken to ensure the non-removal of genuine geologic events from the data.

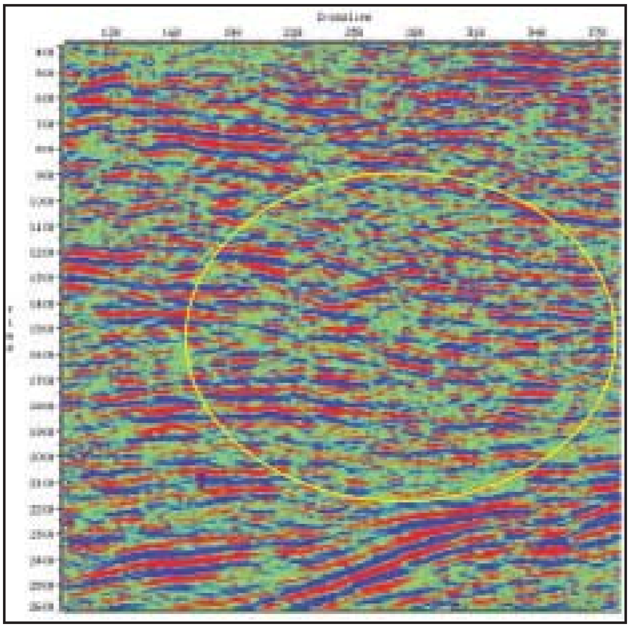


Fig.(3-a): Inline section before footprint removal.

Conclusions

Acquisition footprints can be effectively removed from prestack gathers by applying suitably weighted DMO in order to avoid processing artifacts. The lineations left over in the seismic time slices are also be effectively removed using narrow f-k filtering without risking removal of genuine reflections from geological features. The application of this methodology improves the data quality towards reliable stratigraphic mapping, attribute analysis and inversion results.

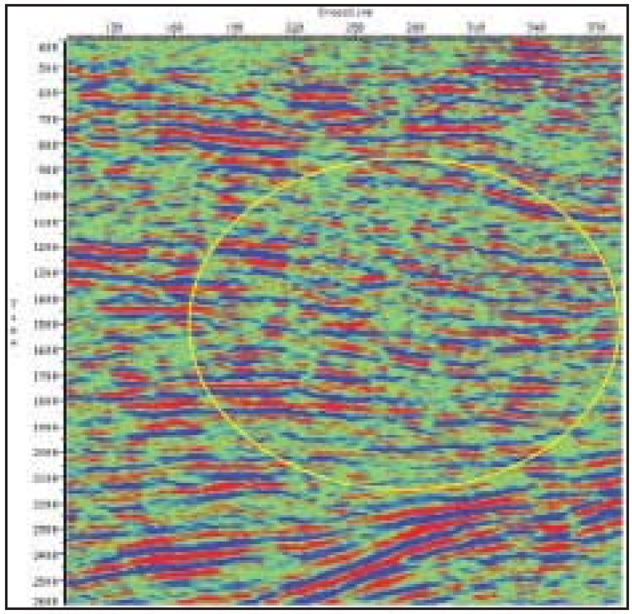


Fig.(3-b): Inline section after footprint removal.

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Views expressed in this paper are that of the author(s) only and may not necessarily be of ONGC.

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