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Acquisition Foot prints in 3D Seismic Data: Causes & Removal during Processing

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Summary

An acquisition footprint is generally attributed as any undesired amplitude and or phase deviation, observed in seismic data caused by surface data-acquisition geometry/patterns rather than subsurface geology. These patterns (foot prints) tend to follow the acquisition geometry used for acquiring the seismic survey. These are usually seen on shallow time slices or horizon amplitude maps in most of the 3D volumes and are nuisance for the interpreter. These acquisition footprints may be generated due to various reasons. Efforts are made to prevent accentuation of the footprint during processing. Despite compensation to irregular fold and offset distribution during processing, these foot prints are still observed, sometimes at deeper level as well. The acquisition foot prints can be removed during post stack conditioning, by enhancement of signal at time slice level for each sample and rebuilding of seismic volume in inline or x-line mode before undertaking meaningful interpretation. In this work, the probable causes and the remedial measures to control the footprints are being discussed by taking an example from Indian offshore Basin.

Keywords*: Acquisition Footprints - Time slice Enhancement, Western Offshore Basin*

Introduction

The footprints are commonly seen as amplitude stripes in time slices produced from a seismic data volume. Since a typical footprint pattern seems to mimic the acquisition geometry, the term "acquisition footprint" is commonly used. An acquisition footprint is an expression of the surface which leaves an imprint on the stack of our 3-D seismic data. Often we recognize it as amplitude and phase variations on time slices, which of course display the amplitudes within our data set at a specified two-way time. More seriously, on horizon slices, footprint can interfere with signal distribution and mask the interpretable stratigraphic plays within the data volume adding confusion to the process of Interpretation.

Causes

Fold, offset and azimuth are the crucial factors of any acquisition design. However, the offset and azimuth distribution can vary from bin to bin or can be uniform in the inline direction and irregular in the cross-line direction. Such variations can lead to undesirable effects on the reflected signal. Deviations from regular geometry pattern, within a 3D survey due to any reason could be responsible for such variation. Azimuthally biased receiver array responses suppress inline noise but at the same time passing cross-line noise. The probable causes for such foot prints may be due to:

- Malfunctioning of the recording system.
- Cable feathering resulting from strong water currents or in the rough sea conditions.
- Undershooting of obstructed areas could be another reason in marine environment.
- Variation in Gun volume and pressure within sail lines or across sail lines may also lead to amplitude variation.
- Post stack interpolation from coarser grid to smaller bin size.

There could be many more causes for acquisition foot prints especially for marine data acquisition. Marfurt et al. (1995, 1998) has discussed the effect of footprint noise on the

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mapping of seismic attributes such as seismic coherency. During the last few years there has been an exponential increase in the number of attributes that can be mapped from seismic data for geological inferences (Brown, 1999). Therefore, it is important to eliminate or at least suppress the footprint noise in data so that the data become not only easier to interpret but also leads to a meaningful interpretation.

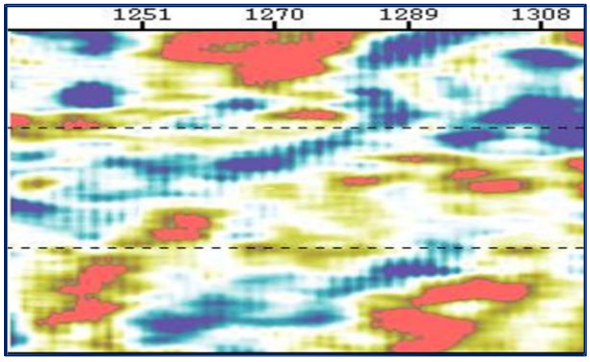

Fig-1: Footprints are seen on Time slice at 500 ms

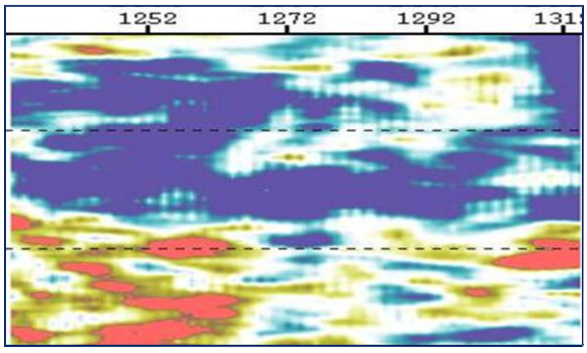

Fig-2: Footprints are seen on Time slice at 2500 ms

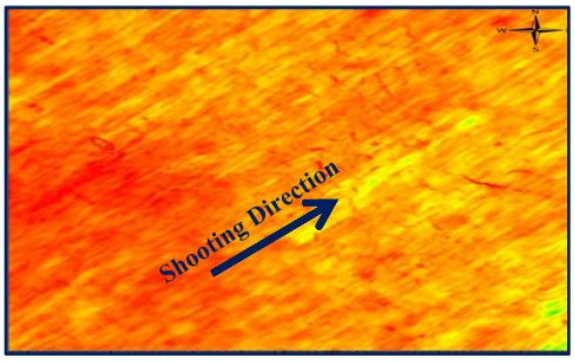

Fig-3: RMS amplitude map at horizon H4 before footprint Removal

Remedial measures

Removal of random noise, linear noise, ground rolls and multiples in the seismic data are essential part of the processing and being done regularly. Irregular fold and offset distribution normally being taken care by regularisation in common offset plane, but azimuthal variation in xline direction remains and affects the reflected signal. Its response is mixed in orthogonal geometry. However, these azimuthal variations can be taken care during pre-stack migration by estimating the trace weights for entire volume and scalars are computed for each trace where the effect of azimuthal variation is minimised. Cable feathering etc. are being taken care by flexi-binning. Despite all above measures which are normally done during processing, still some noise pattern/stripes resembling with the acquisition geometry are seen at the shallow as well as at deeper levels of interest which create confusion about the generated attributes from 3D volume and cannot be correlated with subsurface geological setup. These foot prints are nothing but the periodic variations in fold, offset and source–receiver azimuths which vary spatially and seen on the time slice / horizon amplitude map or other attribute as the back ground and mask the geological information. One of the methods for removal of such foot prints is to enhance the time slices (signal enhancement) for entire volume at each or alternate sample and reconstruct the volume in inline/xline mode before giving it for interpretations. However these processes can also be applied by interpreters on work station provided they have the facility on work station to do so.

Current Example

The present study has been carried out on a marine data from Indian Basin acquired with 3 mtrs gun depth and 3 Nos. of streamer cable at 4 mtrs depth with 25 x 12.5 M grid and flip-flop shots. With all available tools, this volume was processed up to PSTM stack and interpolated to smaller grid i.e.; 12.5 x 12.5 M. in post stack. After large zoom, the amplitude strips along cross lines on time slices & horizon attributes were seen which was periodic in nature and resembles with the acquisition geometry. This was creating nuisance during interpretation. The remnant of these periodic noises may be attributed to an acquisition footprint which is seen on the time slices and horizon amplitude

maps. Fig-1 &2 shows the time slices at 500 ms and 2500 ms whereas Fig-3 shows RMS amplitude map with acquisition footprints.

Time Slice Enhancement

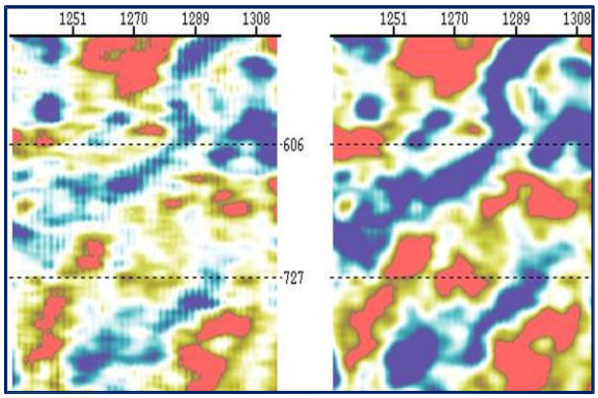

Fig-4: Time slice at 500 ms before & after footprint removal

For removal of these foot prints, time slices has to be improved in terms of signal and amplitude variation using, dip filter in FK domain in X & Y directions, median filter for amplitude, Fxdecon & power enhancement of signal in FK domain. After application of above processes, these noises or so called foot prints were removed without affecting the geological information.

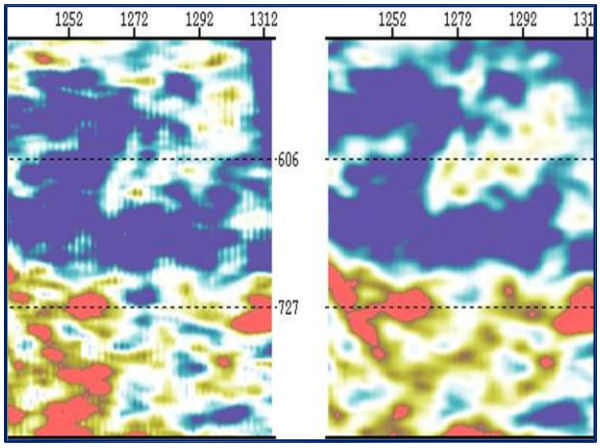

Fig-5: Time slice at 2500 ms before& after footprint removal

After removal of foot prints on each time slice, these time slices were converted into seismic trace and volume. Fig-4, &5 shows the results before and after time slice enhancement. Attributes calculated from this seismic volume after removal of footprints does not show any acquisition geometry related artefacts and provide more meaning full geologic interpretation (Fig-6)

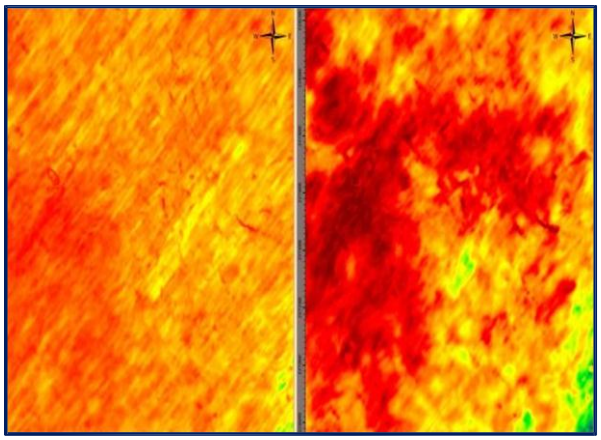

Fig-6: RMS amplitude map at horizon H4 before and after footprints removal

Conclusion

- Acquisition footprint has many different sources /causes. It should be minimized as much as possible hopefully at the recording stage.
- Acquisition footprints can effectively be removed by time slice enhancement using dip filtering in FK domain, and median filtering of amplitudes from slices.
- After removal of foot prints, added advantage is we have a high signal to noise ratio in the output volume.
- Attributes calculated from this volume will exhibit better and clear geologic features without any masking.
- The application of this methodology improves the data quality towards reliable stratigraphic mapping, attribute analysis and inversion results.
- Inline section (Fig-7) after removal of acquisition footprints is free from back ground noise with clarity on the faults
- As an example, notice receiver-line imprints that appear on the time slice on Fig-1 & 2, are not seen on the equivalent time slice in Fig-4 & 5 after the data- acquisition footprint is filtered from the amplitude data.

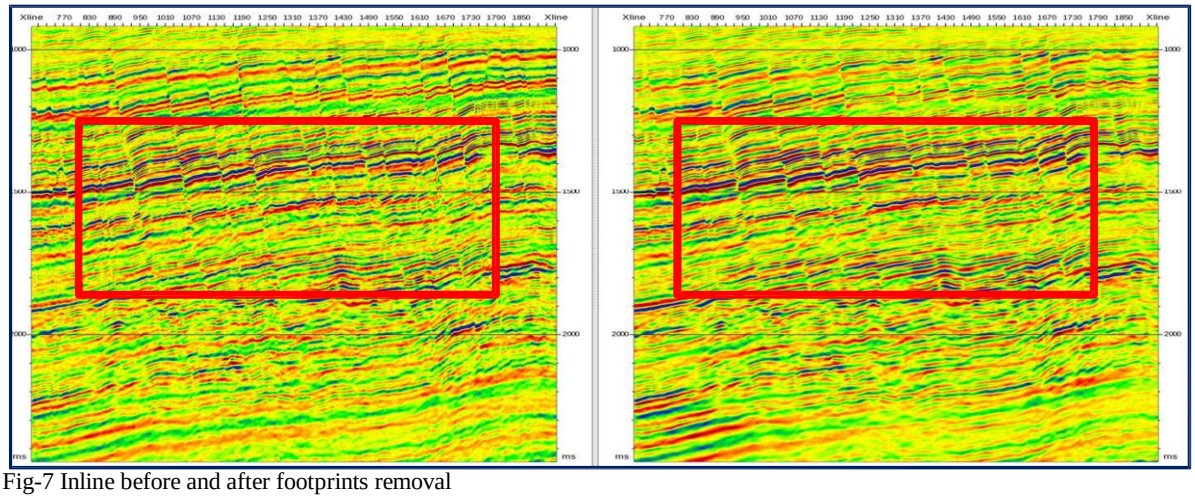

Fig-7 Inline before and after footprints removal

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

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