

# Determination of Tidal Corrections and Application to 3D Marine Data: A case study

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**ABSTRACT:** The present work deals with the study of the effect of sea level changes due to tides on the processing of 3D offshore seismic data acquired over south Heera field. The water column variations due to high/low tides result in raising/lowering the source and receiver positions from the reference datum (MSL). The variations in the water column are of the order of 0-5 m. This introduces time shifts in the travel path in the data recorded during high and low tides with respect to reference datum. To account for these time shifts, tidal corrections were derived with the help of tidal chart and water column velocity and were applied to the data. The correction, though small in magnitude (approx. 7ms), has considerably improved the resolution, standout and continuity of events.

## INTRODUCTION

The study demonstrates how the application of tidal correction can improve the quality of processing of 3D seismic data. Static corrections are important in seismic data processing to determine the reflection arrival times which would have been observed if data had been recorded on a flat reference datum. For normal 2D seismic data the effects of tides can generally be ignored; they, after all, vary very slowly and will hardly be noticeable along the seismic line. But in case of 3D data acquisition, this effect can be significant due to tidal variations along 3D lines recorded at different times. Though the magnitude of 'tidal' statics is small compared to statics in land data, corrections due to this effect may greatly improve the frequency content and reflection continuity. This will, in turn, aid structural and stratigraphic interpretation to a great extent.

The study area, South Heera Field, is one of the major oil producing fields of the western offshore India. It is situated in the Heera-Panna-Bassein Tectonic block of Mumbai offshore. Figure 1 shows the location of the study area. Oil accumulations have been encountered in Panna Formation of Paleocene to lower Eocene age, Bassein Formation of lower Eocene to middle Eocene, Mukta and Heera Formations of lower Oligocene age. Gas accumulation has been found in the upper part of Bandra Formation of middle Miocene age. Minor oil accumulation has also been observed in the basement.

The structure has been delineated on the basis of 2D/3D seismic data. The wedge-out limits of Mukta, Bassein and Panna Formations could not be mapped confidently due to poor standout of the seismic events corresponding to the top of the Panna Formation and basement marker on the conventionally processed 3D data. Therefore a necessity was felt to enhance the signal to noise ratio by the application of

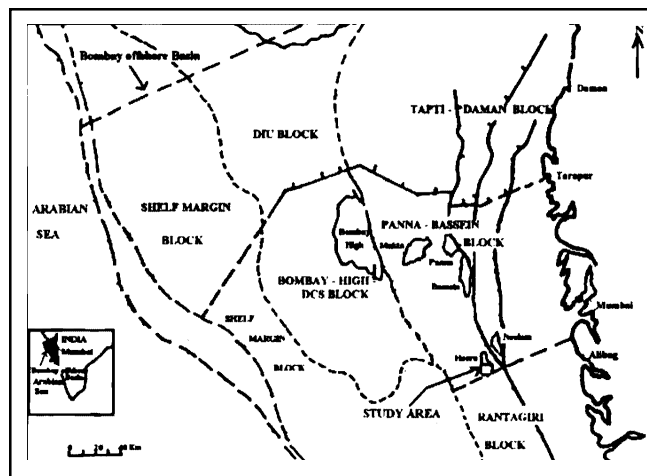


Figure 1: Location Map

all the available means of signal enhancement techniques to increase the resolution in order to facilitate the mapping of the Panna Formation and Basement marker.

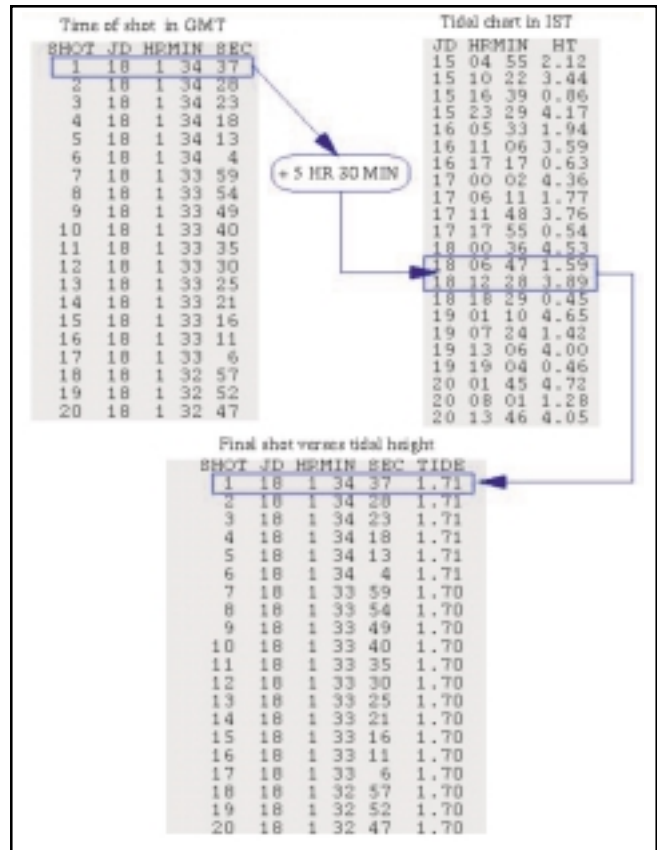
## COMPUTATION AND APPLICATION

The height of water level above the sea bottom changes with a time period of approximately thirteen hours due to tide and ebb. The record of these variations, the 'tidal chart', is obtained from port authorities. The tidal chart used by the authors contained data at an interval of approximately six hours for the purpose of correcting for time delay due to these variations, it was required to compute the tide data, both in depth and in time, for each shot in the survey area. The generic 'spreadsheet' module of any seismic processing software, through which any 'static' correction is applied, requires a shot model in which these values are tabulated against some sequential shot numbers.

In 3D marine seismic data acquisition, it is not possible to maintain shot or FFID numbers sequentially throughout the survey. For the purpose of tidal corrections application and other processes such as surface-consistent amplitude balancing and deconvolution, the shots have to be renumbered in a sequential manner in order to maintain consistency. Then the problem arises as to how the correct tidal corrections may be associated with these renumbered shots. It was found that recording time of the shot (Julian day, hour, minute, second) could be effectively utilized for the above purpose since (i) it is a unique identifier for each shot and (ii) water level variations are given with time in the tidal chart. Accordingly, the renumbered sequential shots and the corresponding time were extracted in an ASCII file from the geometry updated trace headers of seismic data. For each shot number and the time picked up from this file, the tidal value pertaining to that shot was computed by interpolation between two sample points in time given in the tidal chart. In creating the final output file containing sequential shot numbers versus tidal corrections (in depth), 5 hours 30 minutes was added to the time of shot (in GMT) before interpolation between two time samples in the tidal chart because the latter are recorded in IST. The schematic diagram for computing the tidal heights associated with shots is given below.

Thus the required table of tidal corrections (in depth) versus sequential shot numbers was prepared by a software program external to the processing package using the time of shot as the connecting link. The table was then imported to the spreadsheet and the tidal heights converted to time shifts by dividing the heights at each shot and receiver point by the speed of sound in water. The procedure of preparing a ‘shot model’ for the whole 3D survey, carried out for the above purpose, generated additional significant offshoots from the point of view of other processing sequences. Surface-consistent amplitude balancing and surface-consistent deconvolution were also successfully applied to the 3D data volume through this shot model as the shot model is prerequisite for running any surface-consistent process to maintain surface-consistency in true sense.

Application of tidal correction to the data requires tide information to be available in the seismic trace headers. The marine data acquisition geometry (navigational information) is not stored in the project database as it is directly accessed either from the tape or from disk files. Therefore, a shot model containing shot number, coordinates and tidal statics was created and thus the tidal statics information was



Schematic diagram showing the computation of tidal heights associated with shots

put in the project database. Then this information was accessed from the database, put in the trace headers and applied to the data.

**DATA PROCESSING**

Data processing started with scanning of records at an interval of fifty and navigational (geometry) information quality control. The data was processed in a bin size of 12.5x37.5 m. A special scheme of data processing was planned and executed to enhance the signal to noise ratio. The processing flow chart is shown below. First, the seismic trace headers were updated with the navigational information followed by flexi-binning. Flexi-binning was done to obtain uniform offset traces per bin, to fill the data gaps and remove the redundant offsets. Due to feathering the foldage was as high as four hundred traces per bin. Figure 2 shows the initial and final foldage after flexi-binning. Flexi-binning reduced the data volume drastically which saved considerable amount of machine time for the following processes.

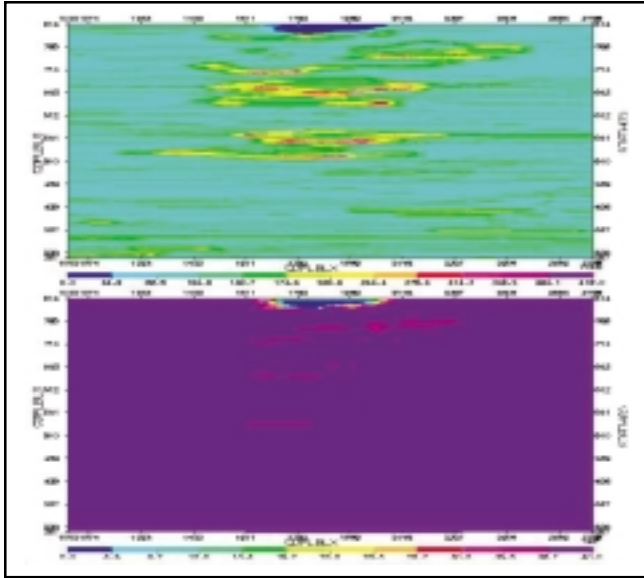
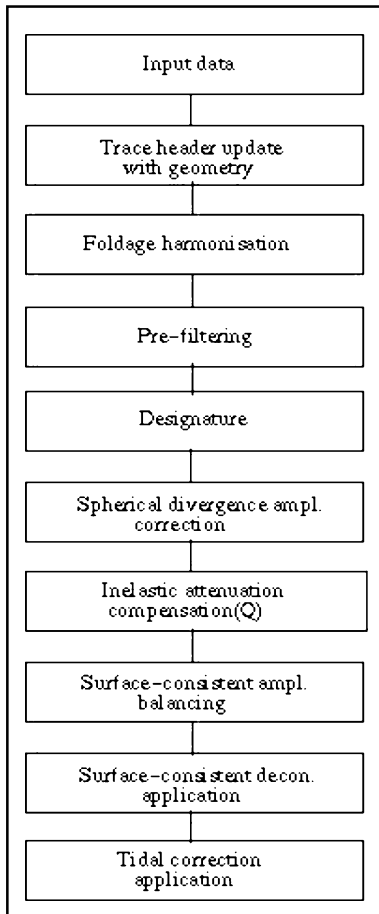


Figure 2: Fold of coverage before and after flexi-binning

Processing Flow Chart



Spherical divergence correction was applied for compensating amplitude losses. For compensating the inelastic attenuation effects,  $Q$  was applied in time domain. Surface-consistent amplitude balancing/scaling was done to compensate for variations in trace amplitude due to differences in source and receiver coupling as well as lateral changes in near surface. Interpretive processes such as AVO analysis or trace inversion, which assume relative amplitude data, produce more reliable results when data have been balanced in a surface-consistent manner. Surface-consistent deconvolution was applied to the data to selectively remove the convolution components contributing to the seismic wavelet with 12 ms gap length, 120 ms operator length and 0.1 per cent white noise inside pass band of 6-125 Hz and 50 per cent out side pass band. Finally, the tidal corrections were accessed from the project database and applied to the data. Figure 3 shows the comparison of the raw and final gather.

RESULTS AND DISCUSSIONS

Figure 4 shows the variations of the computed tidal corrections (time shifts) and tidal heights over the South Heera field. The variation in the tidal heights is of the order of 0 to 5 m. The computed tidal corrections variation is of the order of 0 to 7 ms.

Comparison of part of an inline stack section with and without tidal correction application has been presented in Figure 5. There is remarkable improvement in resolution, standout and continuity of events in section with tidal correction compared to the section without tidal correction.

Figure 6 is a comparison of part of a cross-line (extracted from 3D data volume) with and without tidal

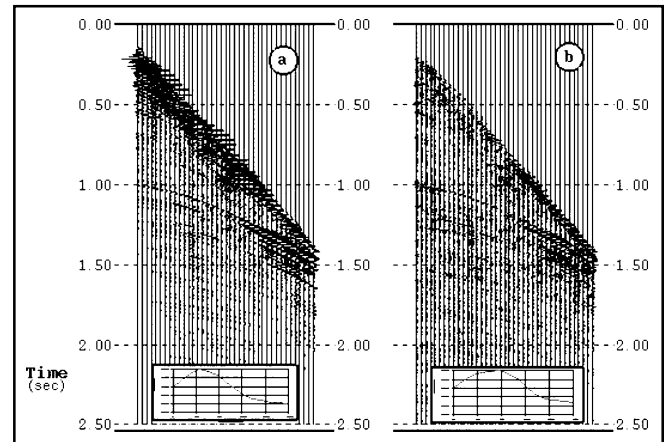


Figure 3: CDP gather (a) raw and (b) final processed

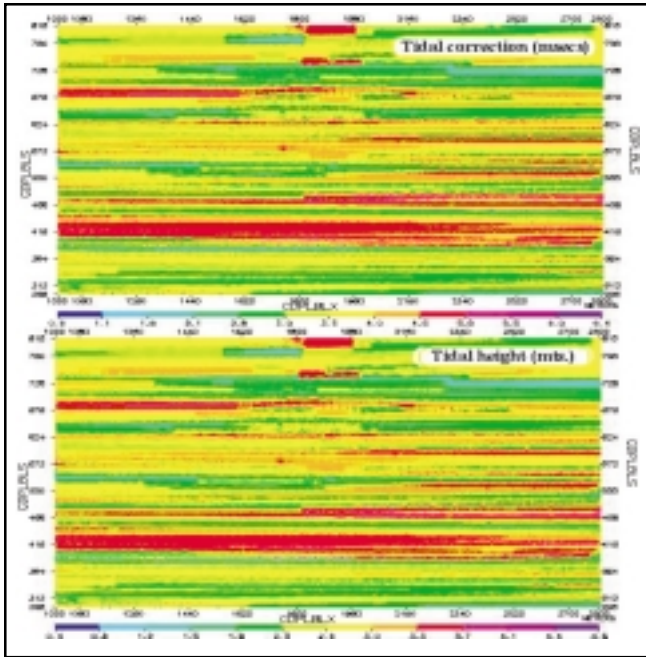


Figure 4 : Tidal variations over the South Heera field

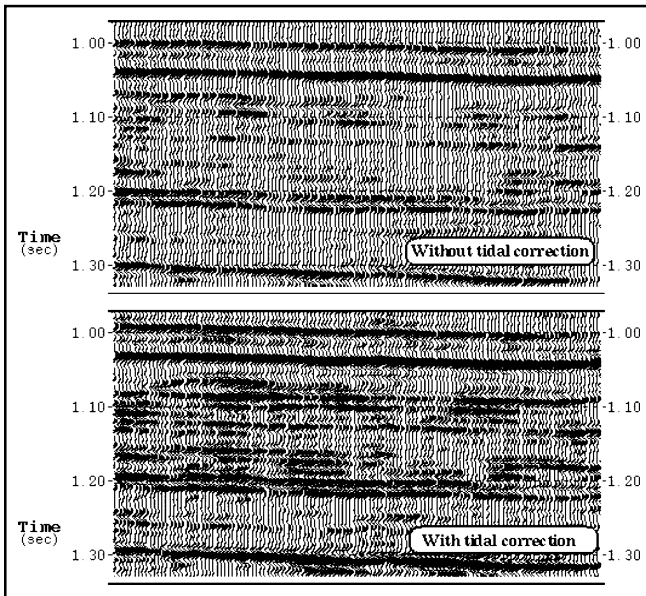


Figure 5 : Comparison of an inline extracted from 3D volume

corrections . Each trace on this section comes from different inline recorded /shot at different time (and possibly in a different direction) The jittery nature of traces can be seen in the section without tidal correction (high frequency static errors from trace to trace by tidal differences) compared to tidal corrected section.

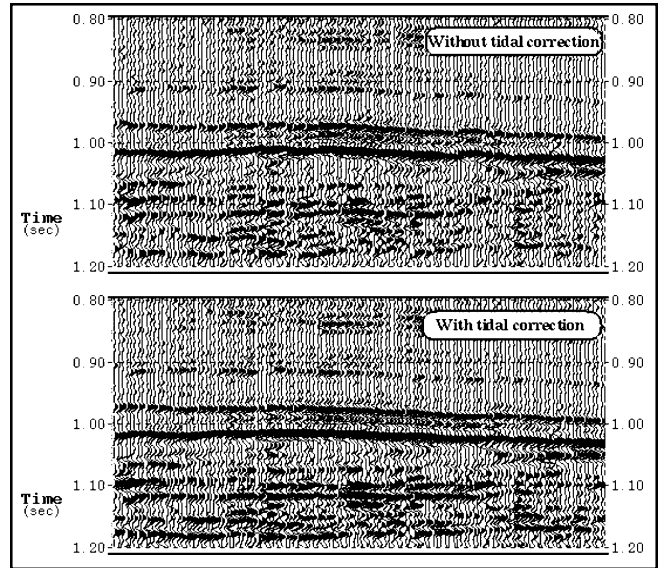


Figure 6 : Comparison of a crossline extracted from 3D volume

## CONCLUSION

In marine areas, though source and cable depth changes due to tide effect are normally small, tidal corrections may be effectively applied to minimise line misties and to enhance signal to noise ratio. In this study tidal statics have brought out significant improvement in the reflection standout, frequency content and resolution. The over all improvement in whole 3D data volume is observed more prominently at places where tidal differences are significant. Tidal corrections have more impact on the cross-lines since the in-lines contributing to it may have been recorded at different times and may have gone through larger fluctuation of tides. Tidal correction application followed by residual static estimation and application has produced dramatic improvement in stacking quality. Results suggest that tidal correction should be applied in routine 3D marine seismic data processing flow.

## ACKNOWLEDGEMENT

The authors are grateful to Dr. C H Mehta, Group General Manager and Head GEOPIC, and Shri K Niyogi, DGM(GP) and Head Processing, for providing the opportunity to carry out this specialized task and their encouragement to write this paper. Thanks are also due to our colleagues in the processing group for their valuable suggestion during the course of this study. The views expressed in this paper are those of authors only and do not necessarily reflect their employer's opinion.