A Comparative study of Wide Azimuth data and conventional data of Cachar fold belt area

Mithun K V, Manoj Kumar Bharatee, Kotnees N and Hanuman Sastry Maduri
Oil and Natural Gas Corporation Limited, Jorhat

Abstract

Designing acquisition geometry is an optimizing exercise to achieve proper subsurface illumination by suitable placement of receivers and shots. Due to the resource constraint, most of the conventional surveys are carried out with lesser crossline sampling than inline sampling. The data is acquired generally in the dominant dip direction and perpendicular to the faults. This often leads to better imaging along the dip direction and slightly inferior strike direction imaging. The azimuthal content in the conventional geometry is often poor. Authors of this paper have tried to assess the impact of a wide azimuth survey upon structural delineation in geologically complex area. For this datasets acquired by two different geometries at the same area, were processed using the same processing flow including the processing parameters and the results were compared.

Introduction

Different methods of acquisition geometries evolved over the years viz., parallel line, orthogonal, slant, zig-zag, brick etc. Each of these methods offer different advantages and disadvantages both technically as well as in practical aspects of implementation.

Technical requirement of acquisition geometry attributes are discussed by Vermeer (2003) and other design experts over the years, and are summarised below:

- Full Azimuth Coverage with good offset distribution within each Azimuth range
- Single Line Roll-Over for Subsequent Swaths to avoid possibility of acquisition footprints
- Equal surface sampling of sources and receivers in X and Y directions
- All aspect ratio(s) to be equal to One
  - Square Bins
  - Equal Max. Offset on All sides of Shot
  - Equal RLI & SLI
- Equal In-Line & Cross Line Fold is preferred
- The range of variation in Near and Far offset must be minimum across Bins
- Uniform distribution of fold in near / mid / far offset ranges
- 3-D sampled Shot gathers

Inspite of this, compromises are made in geometry parameters, especially, when the channel availability with the crew is limited. In most of the conventional geometries crossline fold is sacrificed for the inline fold. The azimuthal distribution is generally skewed. In such cases subsurface geology is seismically illuminated only from one particular shooting direction. We assume that most coherent noise types are well behaved and we can remove them in processing. We assume that the target illumination is acceptably uniform, and we can produce clean seismic images. This study is a comparison between the processed outcomes of two datasets A and dataset B. Dataset A has been acquired by a conventional geometry referred as survey A in this paper and dataset B has been acquired by survey B which is a wide azimuth geometry.

This study has been done from a processor point of view due to which it has been assumed that the field operations while conducting both the survey has been carried out with utmost caution, ensuring proper geophone plantation and selection of proper optimum depths for shot placement throughout the area. Since the area under study didn't have much logistic difficulties, respective nominal folds were observed in the area under study in both the datasets.

Method

The area chosen for this comparative study is the overlap region of Survey A and Survey B (Figure 1). This has been chosen on account of the subsurface complexity. The study area falls over the concealed Banaskandi anticlinal structure within the fold belt of East Cachar region. This region has proven Upper Bhuban pays and isolated bright amplitude anomalies in the region has proved to be gas bearing.

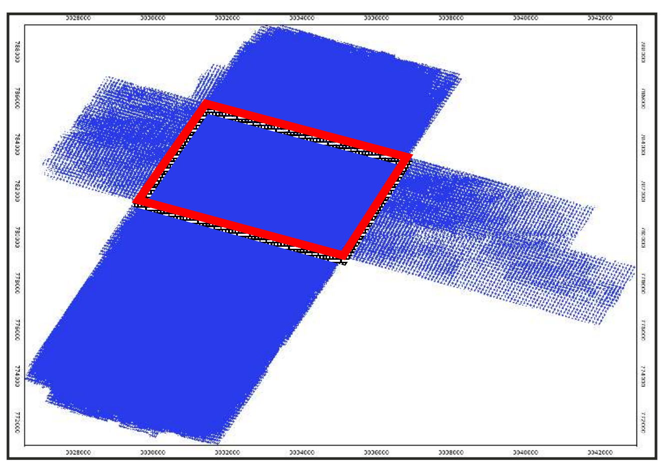

Fig. 1: The data within the overlap region of survey A and B has been chosen for the study. Area is enclosed within red polygon.

The acquisition geometry parameters of the surveys is tabulated in Table 1 and the respective templates illustrated in Figure 2 and Figure 3.

The main aspect that makes the survey B unique and unconventional as compared to the conventional survey A is the lack of any preferential directionality in the shot and receiver placement. The shot grid consists of shots at every 440m grid. Shot point spacing as well as shot line spacing is 440m. In the case of receivers , all receivers are spread out on a 40 m X 40m grid. Survey B can be referred as “directionless”. It has a good azimuthal content. The rose diagram of both surveys are given in Figure 4 & 5. The rose diagram of survey B is indicative of rich azimuthal content as compared to that of survey A. In this aspect, Survey B is a wide azimuth survey.

Since shot placements are farther apart in survey B than survey A, better planning can be done in areas where there are logistics difficulties such as towns and proximity to houses.

Table 1: Comparison between the acquisition parameters of Survey A and Survey B

	Survey A	**Survey B**
Shooting configuration	Sym split spread	Sym split spread
Bin size	20x40 m	20x20 m
Fold	80	(8x8)=64
No. of receiver lines	8	11
No of shots /salvo	48	16
Min offset	28 m	28 m
Max offset	3180 m	4950 m (restricted to 3200m for comparison)
Aspect ratio	0.61	1
Shot line interval (SLI)	320 m	440 m
Shot point Interval (SI)	80 m	440 m
Receiver line interval	240 m	40
Group interval	40 m	40
No. of receivers per line	160	176

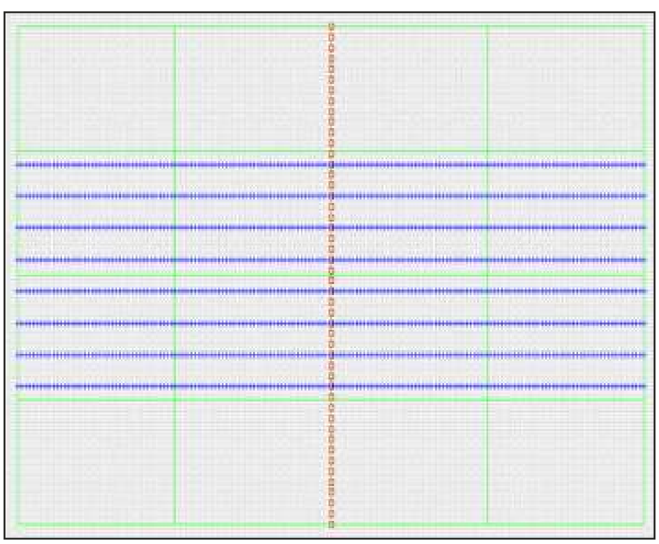

Fig. 2 : Unit template of Survey A

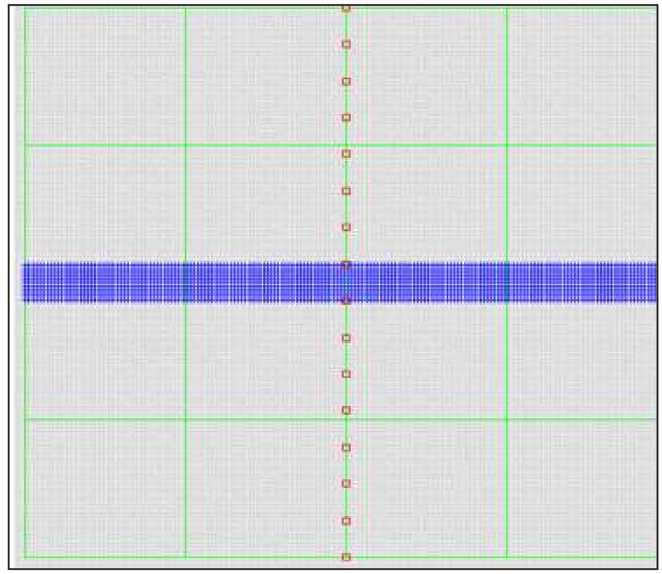

Fig. 3: Unit template of Survey B

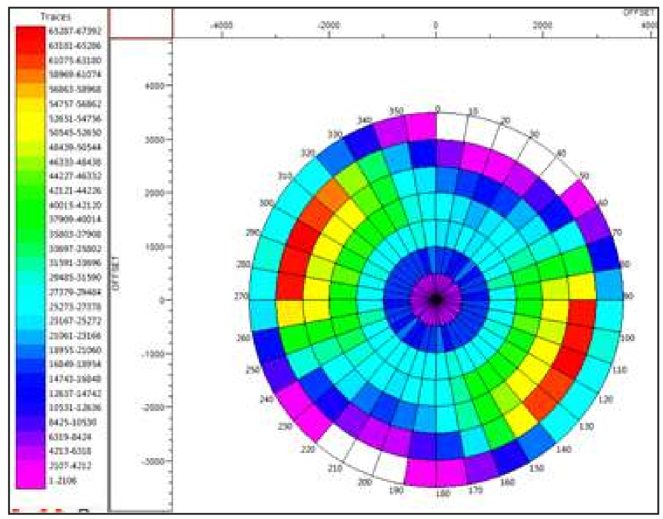

Fig. 4: Azimuthal distribution in dataset A

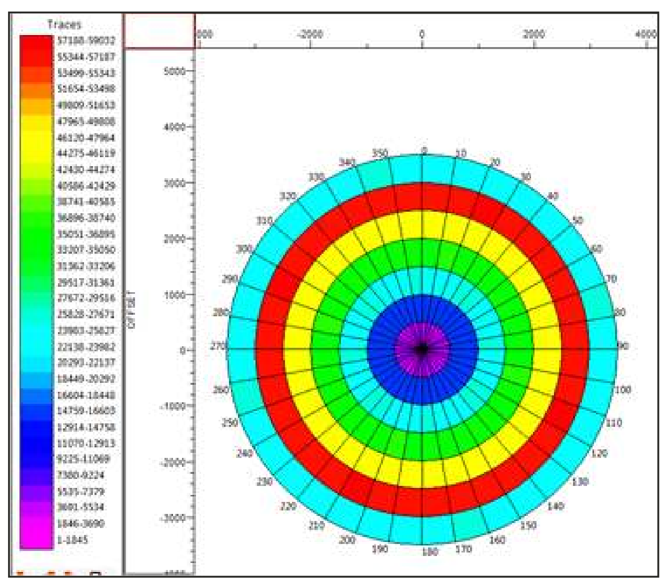

Fig. 5: Azimuthal distribution in dataset B

Since there are no directional constraints, shooting sequence can be conveniently decided. The receiver patch area of the template is reduced to a large extent and maintaining the line connectivity becomes easier. As we have receivers at 40 m. interval in all directions of the shot location, using this fully sampled shot gather of Geometry B all types of shot generated coherent noises from any direction of the shot can be effectively suppressed in processing.

Processing Sequence

Both datasets, A and B were processed using the same processing flow. Denoising was done in the Fourier domain and spiking deconvolution with an operator length of 300 ms was applied on both datasets. Residual statics was computed using Monte-carlo statics computation method. Data was regularized using 5d interpolation module. But datasets has

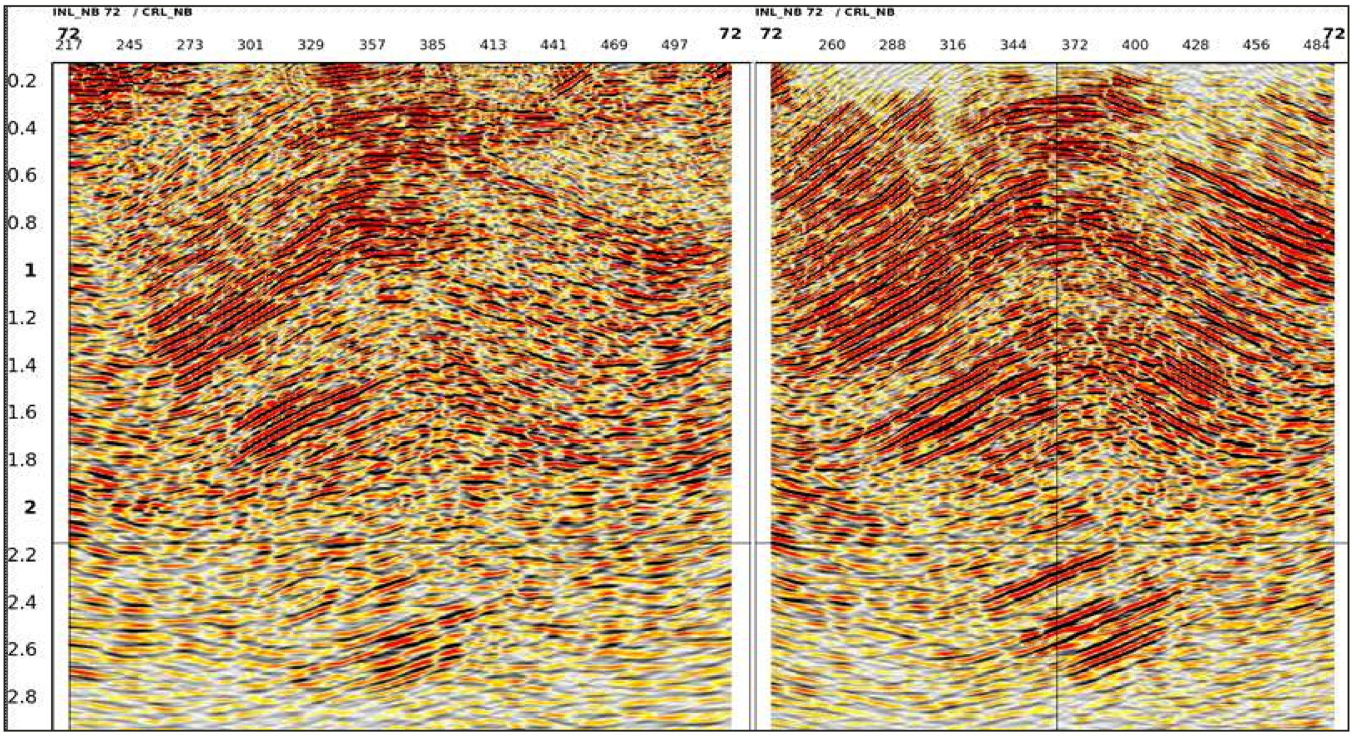

Fig. 6: Final prestack time migrated section along Inline72. Conventional section is on left and WAZ section is on the right side

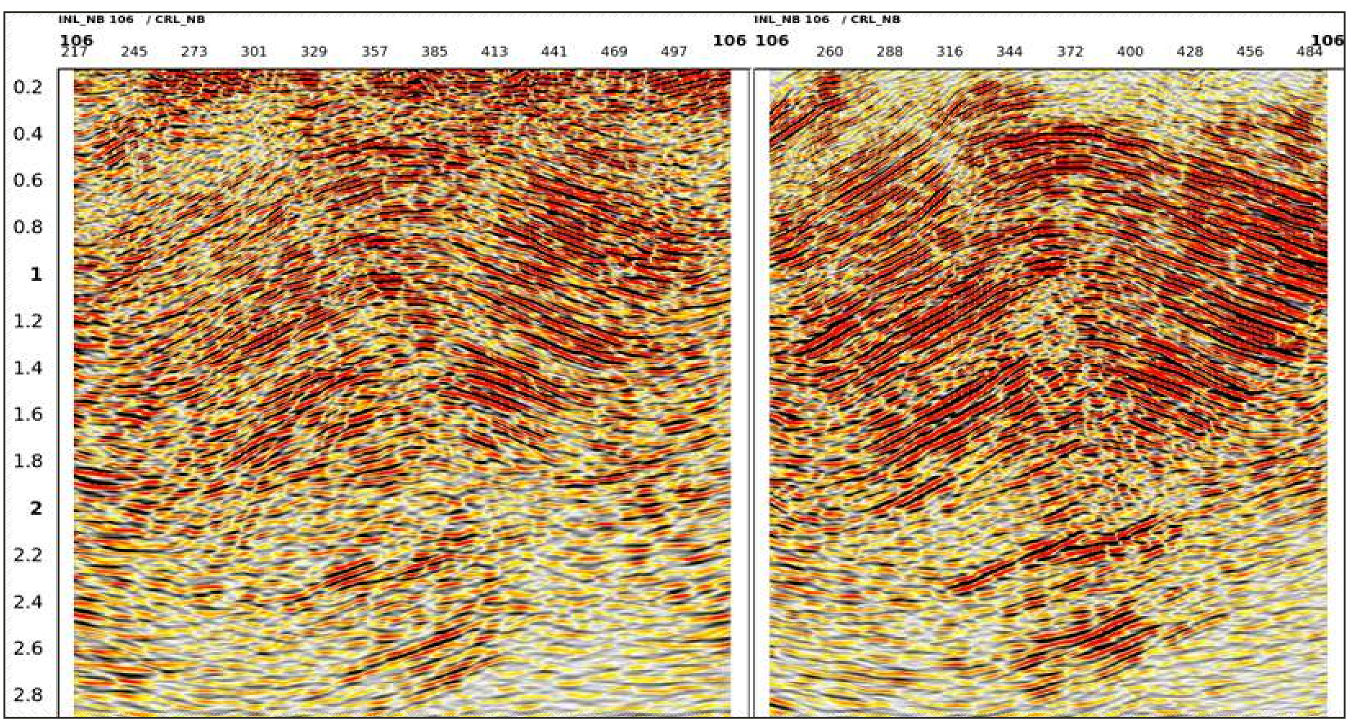

Fig. 7: Final prestack time migrated section along Inline106. Conventional section is on left and WAZ section is on the right side

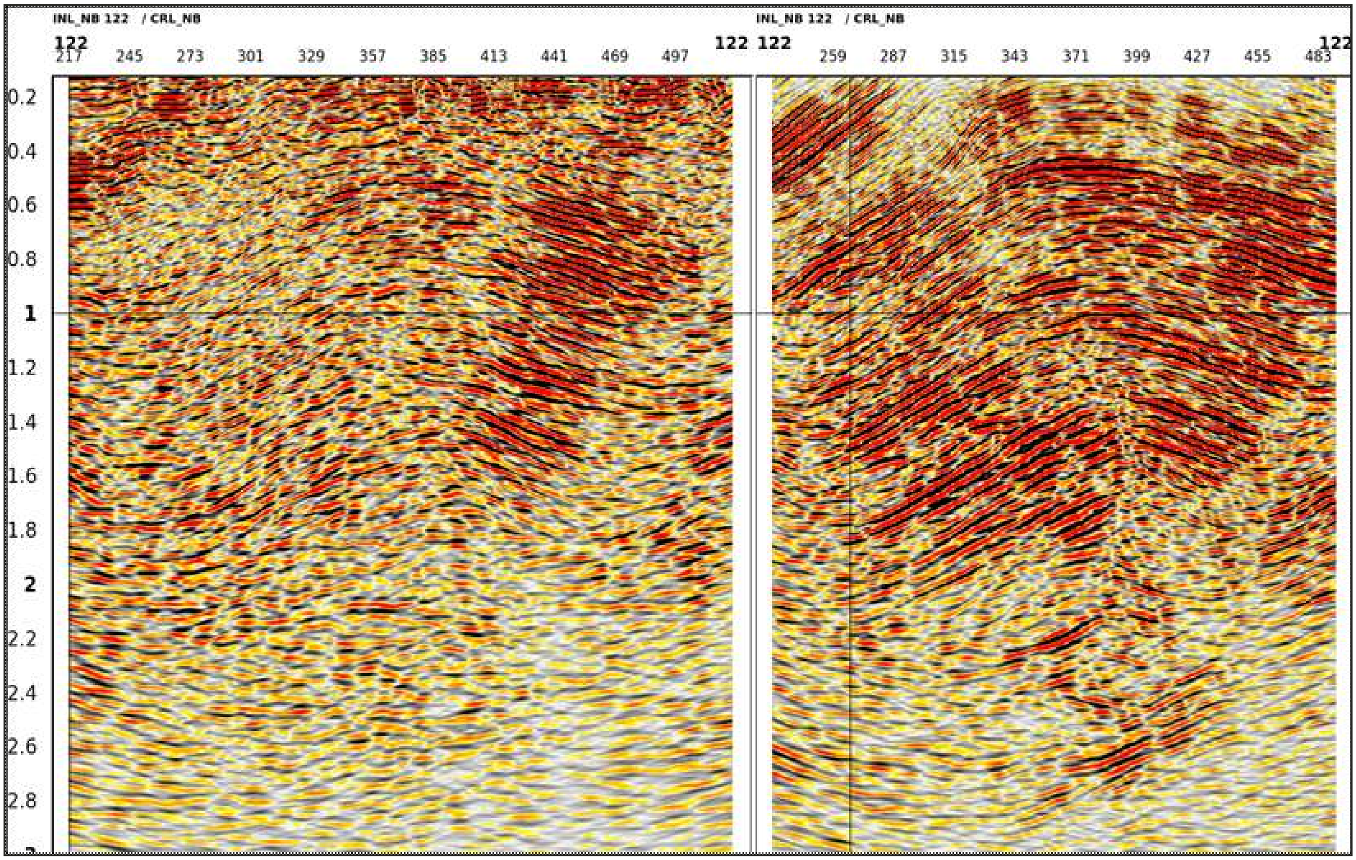

Fig. 8: Final prestack time migrated section along Inline122. Conventional section is on left and WAZ section is on the right side

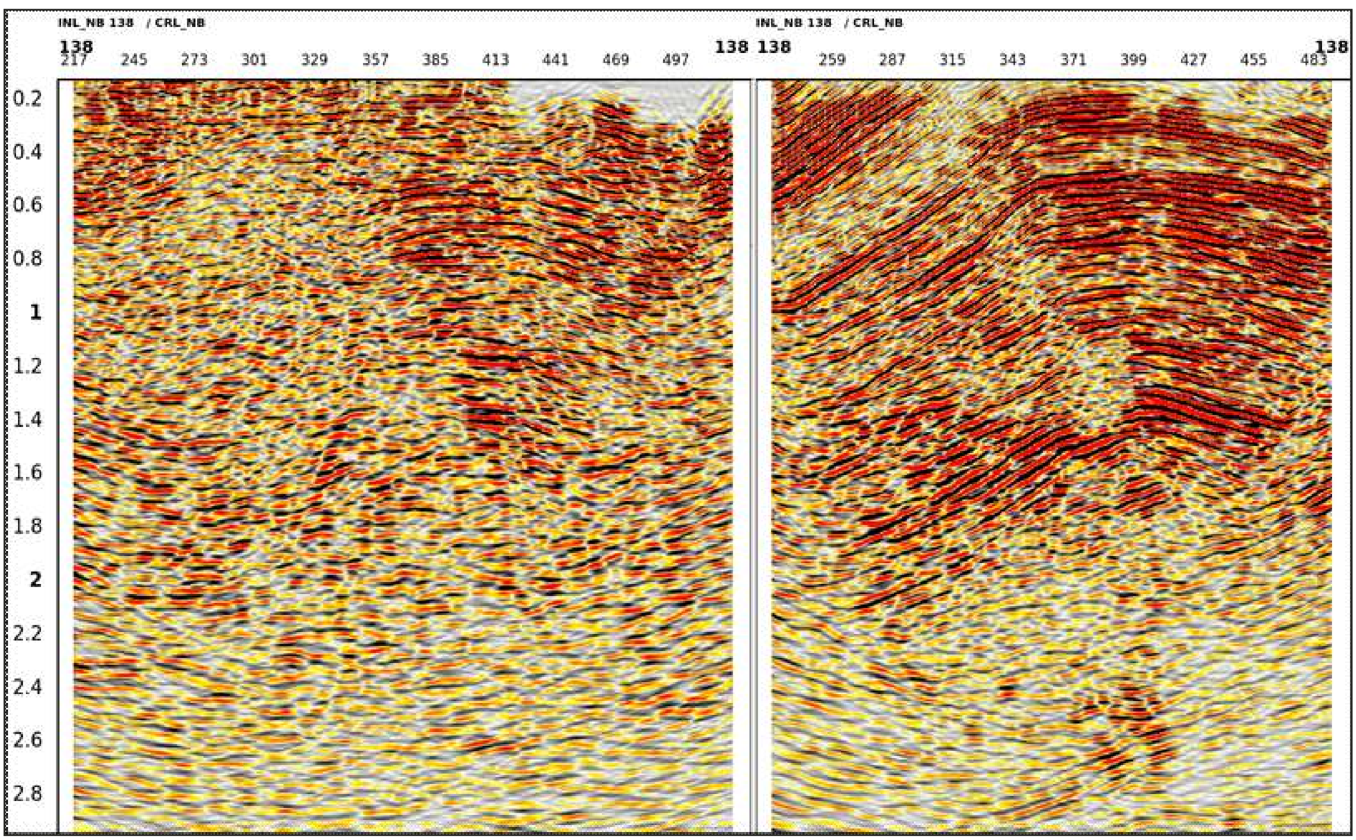

Fig. 9: Final prestack time migrated section along Inline138. Conventional section is on left and WAZ section is on the right side

not been regularized in the azimuthal dimension. At no stage of processing, the parameterization for processing data set A and B differed. Stacking velocity at different stages as well as RMS velocity used for migration were kept same so that the difference in the final processed output need not be attributed to such factors. Anisotropy has not been taken into consideration as offsets were restricted. A level playing field was provided to both the datasets due to which a conventional processing flow was chosen rather than WAZ friendly processing flow. Azimuthal dependence of velocity has been discarded.

It can be observed from Fig. 1 that both the survey strips are perpendicular to each other. Finally, in order to compare the processed output, both the surveys has been brought to the same grid. Since bin size of grid B is 20m X 20m as compared to the 20m X 40 m bin size of grid A, the final processed section of A when converted upon to grid B suffered heavy degradation in quality. So grid A was chosen as the common grid. There wasn't much variation the quality of B section inspite of grid change. This can be attributed to the lack of preferred directionality in the WAZ data .

Result

The final migrated Sections are given below. Few sections along in line and few along crossline direction are given for comparison.

The anticline is more structurally defined in section B as compared to section A. In section A, the clarity of the imaging is inconsistent as both flanks of the anticline couldn't be mapped in most of the inlines. Whereas in section B both flanks of the anticline could be consistently traced out. Through out the volume, section B was more superior to section A, both in inline as well as crossline direction. Fault definitions, isolated high amplitude anomalies, channel relicts and other relict features could be mapped better in section B rather than section A.

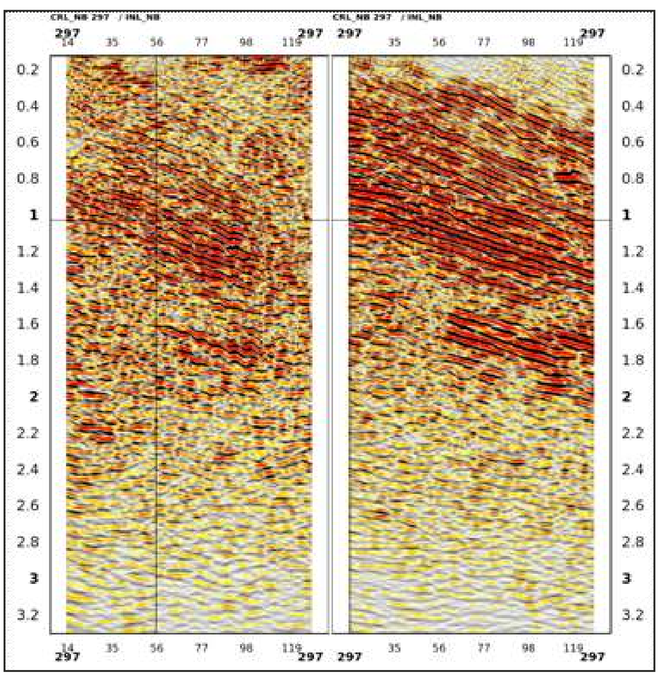

Fig. 10: Final prestack time migrated section along crossline 297. Conventional section is on left and WAZ section is on the right side

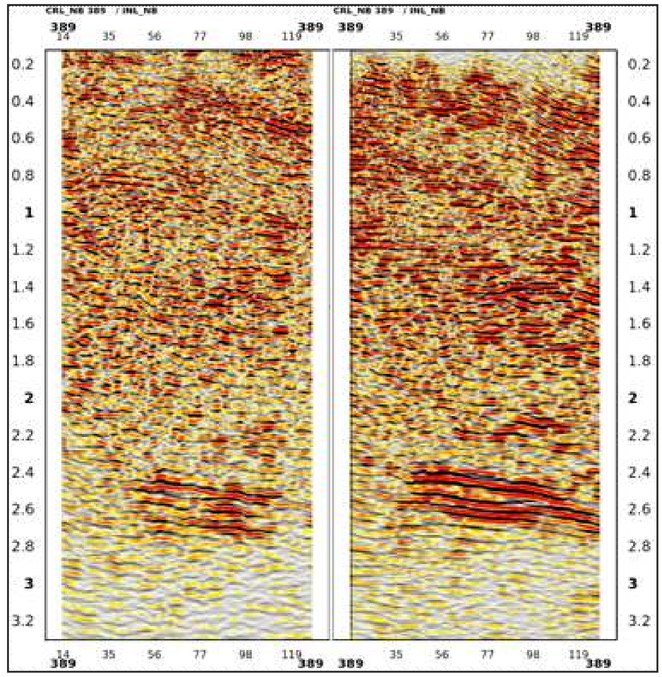

Fig. 11: Final prestack time migrated section along crossline 389. Conventional section is on left and WAZ section is on the right side

Conclusion

Since both the datasets have been processed using same parameters including velocities, it is reasonable to conclude that imaging difference among the two sections is a direct result of the inherent geometry design. Finer sampling of the wave field is required in both dip and strike direction with rich azimuthal distribution in order to map subsurface complexities. In section B, a considerable improvement in the imaging of the Banaskandi anticline as well as certain relic features could be observed. With conventional processing flow itself the result of WAZ data is far superior than data acquired using conventional geometry in this case. The authors of this paper restrain from making sweeping generalizations to all complex subsurface geological setting from this single comparative study presented in the paper. Further studies can be carried out in different regions and across different geometries before generalizing the result on a larger scale.

Acknowledgements

The authors express sincere gratitude to Dir.(E), ONGC, India for permission to publish this work. Thanks are due to Basin Manager, ONGC Jorhat and HGS, ONGC Jorhat for the support and encouragement they had provided. Thanks are due to N.M. Dutta for encouraging us to takeup this case study and giving valuable inputs regarding various investigations and processing history in the area. We are indebted to A

Rahaman who has helped us with the geological aspects of the region and conveyed an interpreters perspective to us while processing. The views expressed in this paper are exclusively those of the authors and need not necessarily match with the official views of ONGC.

References

Hanuman Sastry Maduri, Agarwal D.N., An implementable alternate survey geometry design for Land 3D Seismic Acquisition.

Ruben D. Martinez, Jon Burren, and Ernesto Lemos (2011) Challenges and solutions in wide azimuth seismic data processing and imaging for geologically complex areas. 12th International Congress of the Brazilian Geophysical Society & EXPOGEF, Rio de Janeiro, Brazil, 15–18 August 2011: pp. 1212-1215.

Sandeep K Chandola et al, Dip or Strike? – Complementing geophysical sampling requirements and acquisition efficiency. SEG Technical Program Expanded Abstracts 2015: pp. 110-114.

Bruce J. VerWest and Dechun Lin (2007). "Modeling the impact of wide-azimuth acquisition on subsalt imaging." GEOPHYSICS, 72(5), SM241-SM250.

3D seismic survey design optimization, The Leading Edge, October – 2003 issue.