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Processing of Multicomponent (2D-3C) Data of Satpura Basin: A Case Study

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Summary

Multi component survey have become one of the leading areas where state of the art technology is being applied to areas where the exploitation potential has not been fulfilled due to difficulties in obtaining an interpretable seismic images. Converted shear wave data allows images to be obtained that are unobstructed by the gas and / or fluids. This reduces the risk for interpretation and subsequent appraisal and development drilling in complex areas which are clearly petroleum rich. In addition, rock properties can be uniquely determined from the compression and shear data, allowing for improved reservoir characterization and lithologic prediction.

Results from the 2D-3C data, acquired in Satpura Basin will be presented. Intrusive rocks present in the area affected the compressional and mode converted shear data. The area also shows the presence of no. of faults and the delineation of fault pattern may be useful for hydrocarbon exploration in this area. ACP stack for mode converted (PS) data was generated after estimation of V_p/V_s ratio. Receiver static was estimated for better imaging of radial and transverse component. Processing of all the component was attempted for fully integrated interpretation of structure. Data acquisition and processing of multi component 2D data sets involves both similarities and differences when compared to conventional technique. Processing for the compressional data is the same as for a conventional survey, however asymmetric ray paths for the converted waves and the resultant effect on fold-offset-azimuth distribution, binning and velocity determination requires radically different processing methodologies.

Introduction

2D-3C data was acquired by ONGC in Bahamoni- Bhajipani-Delakhari area of Satpura Basin during the field season 2006-07 as shown in fig1. The objective of the survey was to confirm the hydrocarbon prospectivity in the area. Satpura Basin is well demarcated by the exposed basement rocks in the south, blanketed by Deccan traps on the eastern side and to the north, it is mostly bounded by alluvium with patches of exposed basement and Deccan traps. The major exposed geological formations belongs to Permian, Triassic and Cretaceous period. There are extensive basic intrusive rocks within the Basin limits. In Satpura Basin, the sedimentation accompanied by active subsidence is believed to have taken place during Permian and Triassic period. During the Jurassic-late Cretaceous periods, some upliftment activities might have taken place along with a considerable drop in the rate of subsidence. Like other Indian Gondwana Basin, Satpura Basin also had experienced considerable uplift and

erosion in the post Cretaceous period i.e. after the Deccan trap volcanism.

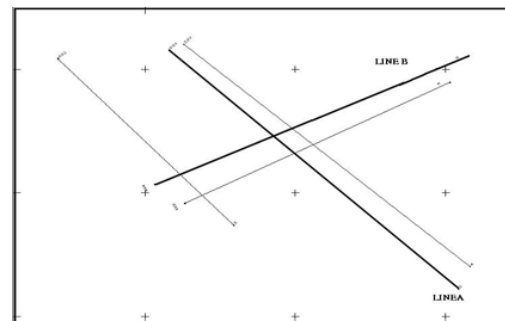


Fig.1 Location Map showing Line A & B



Data was acquired in Satpura Basin with the following geometry.

Foldage	17200%
Group interval	25m
Source interval	25m
No. of channels	344
Far trace offset	6487.5 m
Type of shooting	Asymmetric split spread
Sampling interval	2 ms
Instrument	System Four
Sensors	SVSM 3C single digital sensors

Digital point sensors have advantage of removing intra array statics and preserving low frequencies in recording the full seismic signal bandwidth

Theory

Processing methodology is quite different when considering shear wave propagation or PS converted waves. A shear wave processing sequence is basically similar to a conventional P mode processing sequence, provided that birefringence can be ignored. Because of the asymmetric characteristic of the P-S ray paths shown in fig2, its

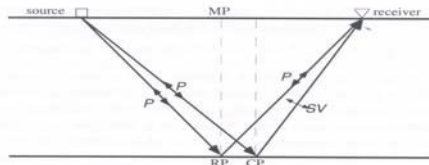


Fig2. PS Ray Path

processing is difficult and different than the P-wave processing. For an isotropic medium with a flat reflector, the P-P ray path is symmetric whereas the P-S raypath is asymmetric due to the fact that the S wave velocity is lower than the P wave. Moreover, their polarization directions are also different. In the processing of PS data, the main concern is to define an approximate value of the velocity ratio (asymptotic) to start the processing: statics, approximate velocity field, partial stacks. Asymptotic ratio can be obtained by associating on PP record (Vertical) or PS record (Horizontal) reflections that should be due to the same geological interface. The efficient ratio, obtained by observing the lateral shift between partial stacks including respectively positive or negative offsets, is used for final stack or migration.

When no azimuthal anisotropy exists, the processing is said to be in VTI environment, the processing is concerned only for radial component, the transverse component can be discarded. In the presence of the azimuthal anisotropy the line orientation does not coincide with a natural orientation of the shallow geo materials and PS1 and PS2 modes have to be separated before further processing.

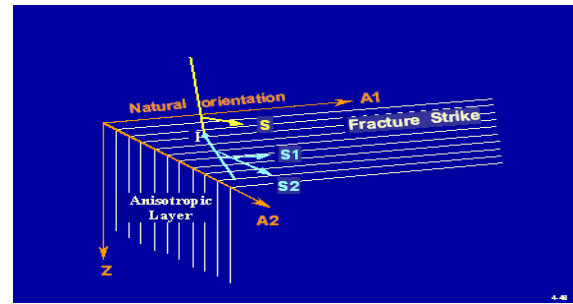


Fig.3 Shear Wave Splitting

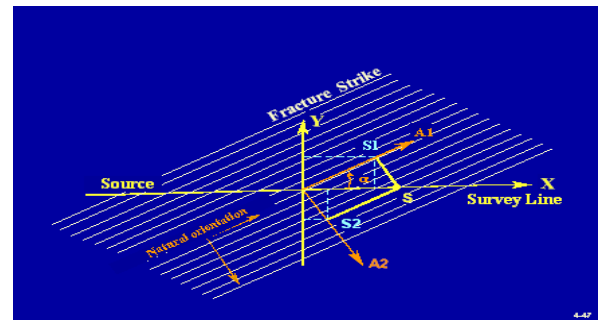


Fig.4 Survey Oblique to axes of anisotropy

Azimuthal anisotropy is observed in a variety of rocks, particularly in carbonates affected by fractures and in rocks submitted to tectonic stresses. In such cases the shear mode original polarization, generated from a shear source or by a PS conversion, is split into two orthogonal components conventionally called natural orientation or natural coordinates (fig.3). Since acquisition coordinates generally do not coincide with the natural coordinates, the radial and transverse receivers

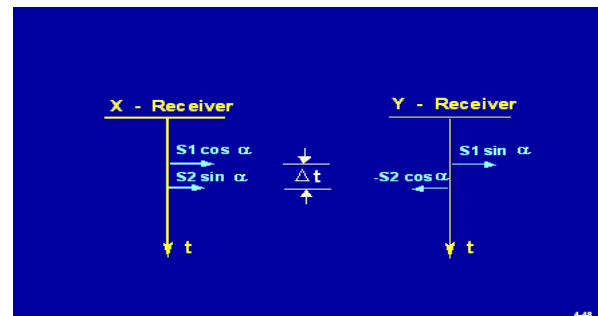


Fig.5 Reflection spike model

record projections of S1 and S2 (fig.4). In the time domain, the spikes produced on radial and transverse components are shown in fig.5.

Processing

The present study is related to processing of vertical, radial and transverse components of data of two lines A & B as shown in fig1

The first step of multi component time processing was to process conventional P wave data upto the optimum



stack. Therefore, these two lines were processed after reconditioning of the raw data and finalization of processing parameters for vertical component. The P wave image itself is very helpful to guide PS processing.

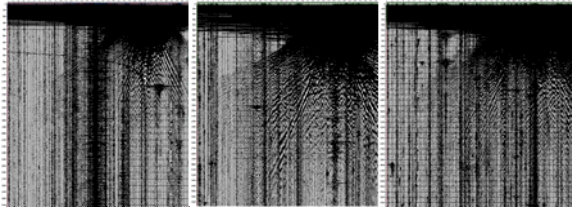


Fig.7 Raw data of Vertical, Radial and Transverse Component along line A

The raw data of all the three components are shown in fig7 and P wave processing results are shown in fig8, fig9, fig10 and fig11 respectively. The continuity of events is affected by the presence of intrusive body in the area

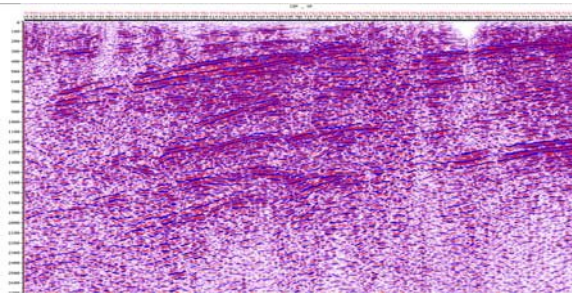


Fig.8 Stack Section of Vertical Component of line A

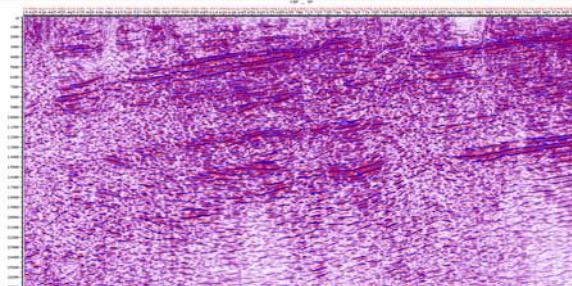


Fig.9 Migrated Section of Vertical Component of line A

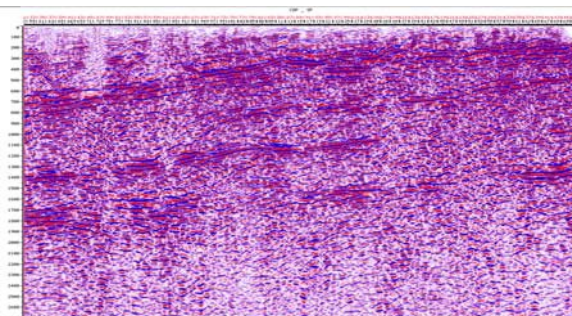


Fig.10 Stack Section of Vertical Component of line B

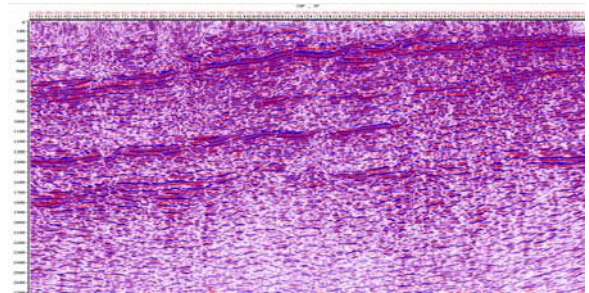


Fig.11 Migrated Section of Vertical Component of line B

For processing of PS data, first Gamma (V_p/V_s) was calculated using travel time of P and PS gather. This gamma was used in ACP sorting of radial component data. For each horizontal and source receiver orientation, the sign of the data changes with the direction of the energy source with respect to the receiver. For 2D, flipping the polarity for positive offsets solves the problem. Estimation of receiver static in PS processing is very important. Therefore S wave receiver static was estimated by multiplying P wave receiver static with initial gamma. Shot static was applied same as for P wave data. Further improvement in the S wave static was attempted after correlating the events on common receiver stack for vertical and radial component data.

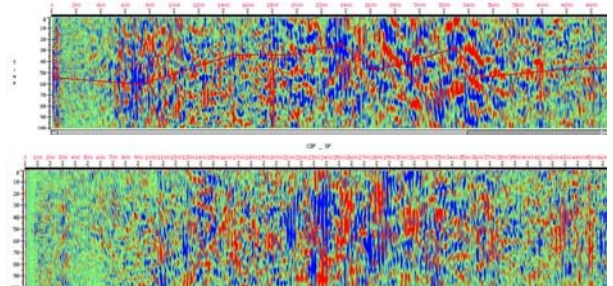


Fig.12 Semblance Plot

After estimating PS velocity for marker horizons with the help of P wave velocity, velocity functions were derived at regular interval on the PS data of the lines. These velocity functions were used for generating the stacks sections for test processing. After PS velocity estimation, two stacks were generated for positive and negative offsets. These two ACP stacks were

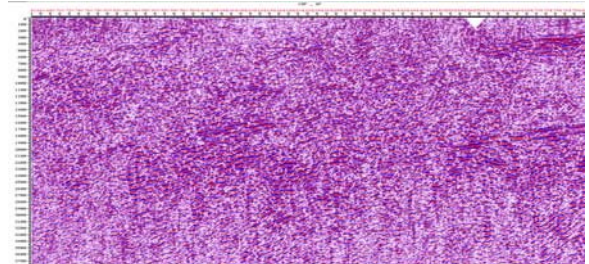


Fig.13 Stack Section of Radial Component of line A



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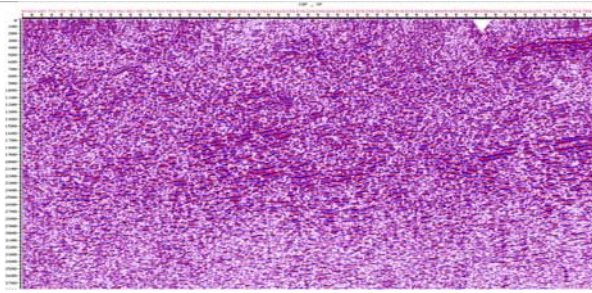


Fig.14 Migrated Section of Radial Component of line A

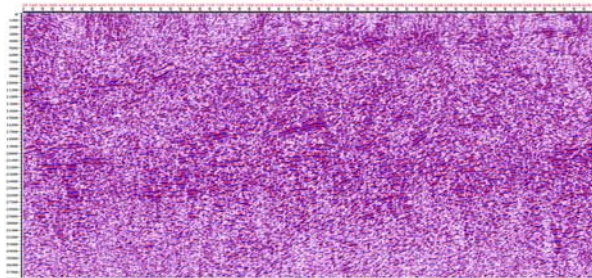


Fig.15 Stack Section of Radial Component of line B

rotated to get transposed stacks in which space axis is converted to time axis and vice versa. Transposed sections were cross correlated in different windows to get semblance at different locations on the profile as shown in fig12. Gamma values were estimated from semblance plot after picking maximum coherency from reference locations. Using main processing steps discussed above and after finalization of other processing parameters, the stack and migrated sections for radial components were generated as shown in fig13, fig14, fig15 & fig16. Processing of transverse component was also done adopting the same methodology and stack and migrated sections are shown in fig17, fig18, fig19 & fig20.

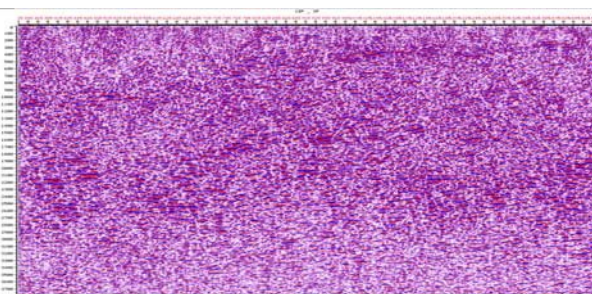


Fig.16 Migrated Section of Radial Component of line B

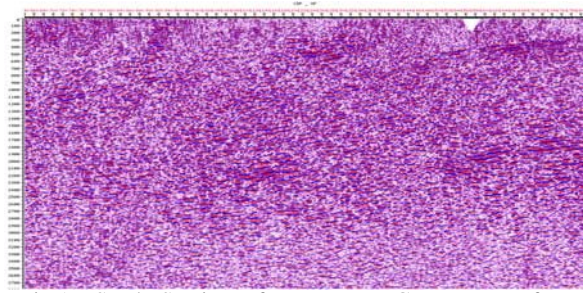


Fig.17 Stack Section of Transverse Component of line A

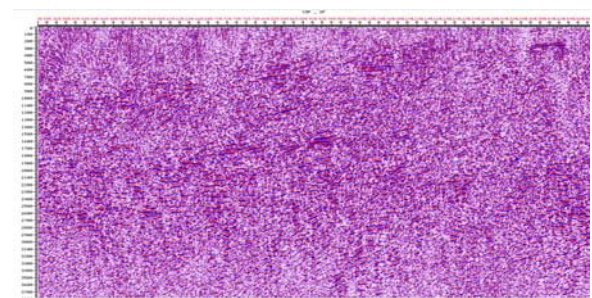


Fig.18 Migrated Section of Transverse Component of Line A

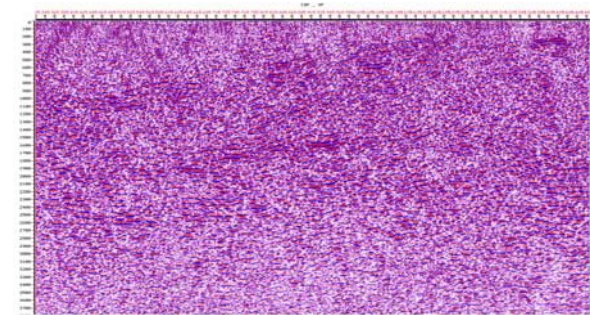


Fig.19 Stack Section of Transverse Component of line B

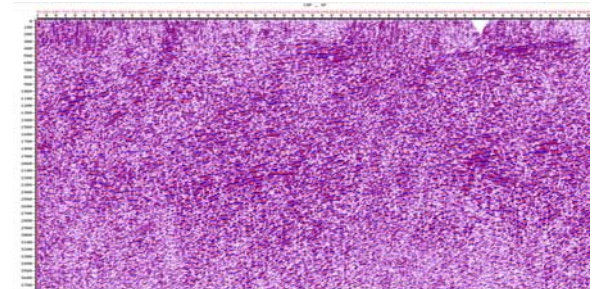


Fig.20 Migrated Section of Transverse Component of Line B



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Conclusions

The stack and migrated sections of P wave does not show continuous events but fault pattern in the zone of interest is well delineated on the vertical section and it may add some value in hydrocarbon exploration in the area. Processed outputs of Radial and Transverse component indicate that mode conversion of down going compressional waves is taking place at the point of reflection. The stack and migrated section of Radial and Transverse components also do not show continuity of events, which makes picking of horizon and matching of events of Vertical and Radial component difficult for receiver static refinement and estimation of gamma function. Some prominent events seen on transverse section are indicative of azimuthal anisotropy in the area. The rotational analysis will be attempted in future to improve the imaging of shear wave components.

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