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A feasibility study for full wave seismic imaging in Cauvery basin, India

O.P.Singh*, P.L.Chamoli, S.M.Pugazhanthi & K. Ramakrishna
RCC, Geophysical Services, ONGC, Chennai

Summary

After the introduction of high channel count systems and 3 component geophones in in-house field crew and Multi component seismic processing package at Regional Processing Centre, a feasibility study for Full wave seismic imaging project was carried out. Modeling studies for acquiring PS data in Kuthalam field of Cauvery basin were done as first step. One 2D3C Seismic Line was shot in the field after designing the acquisition parameters based on the result of modeling studies. The 2D3C data shows good penetration of PS energy and it seems that a full wave seismic imaging project after the acquisition of 3D3C data in this area is feasible.

Introduction

Full wave seismic imaging (Multi component seismic) requires faithful recording of entire seismic signal that the earth can provide. With the introduction of high channel – count systems combined with three component (3C) digital sensors, the fully compliant full wave on-land surveys have become a practical reality (C. Jason, 2007).

Shear wave information can improve both seismic imaging and reservoir characterization. Changes in reservoir quality can often be detected by combined use of P-wave and Swave recording. S-wave arrivals give useful information about fracture distribution and orientation because S-waves are much more diagnostic than P-waves of anisotropy in rocks. Another application is in imaging reservoir with gas charged over burden where the varying gas saturation play havoc with the P-wave image but has much less effect on the S-wave image. The advantage and use of S-wave data has been well documented by Stewart et al (2002).

Towards preparation for 3D seismic multi-component survey in Cauvery Basin, India, one 2D3C Line data was acquired during the month of June 2009. The aim of this test line was to know about the area with respect to PS mode penetration and resolution for optimum design of field geometry. A seismic modeling study was also undertaken before the actual field work.

Seismic Modeling

A seismic modeling study was undertaken before the actual data acquisition to find out the feasibility for the multicomponent data acquisition in Kuthalam field and to help the designing of acquisition parameters for test survey. Seismo-geological model of the area was prepared using Geological and Geophysical data as shown in Fig. 1.

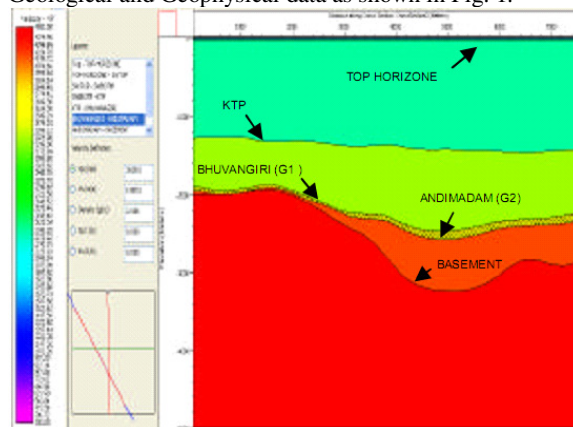


Fig. 1 Seismo- geological model

Shot gathers were generated for 2 no. of 2D lines (Line 01 & Line 02). The location of these lines are shown in Fig.2



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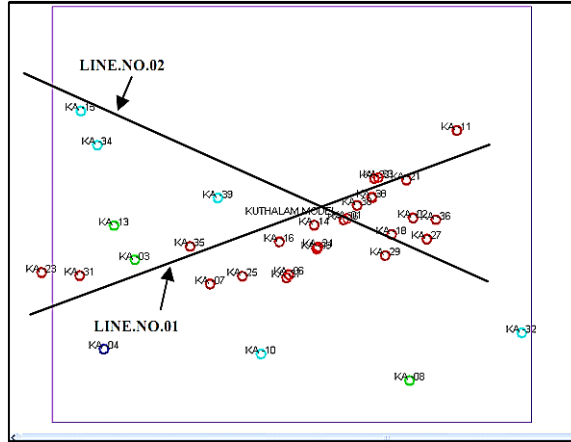


Fig. 2 Location of Line 01 & Line 02

Following recording parameters were used for generating synthetic shot data.

Gr. Int	10 m	Far Offset	5000
Shot Int.	50 m	No. of Shots	340
Channels	1000	Shooting Line Length	27 km
Type	SSS	fold	100

Short group interval is required for better attenuation of ground rolls present in the field data, particularly PS component. Synthetic data generated for both the lines were processed and PP and PS sections were prepared as shown in Fig. 3 and Fig. 4.

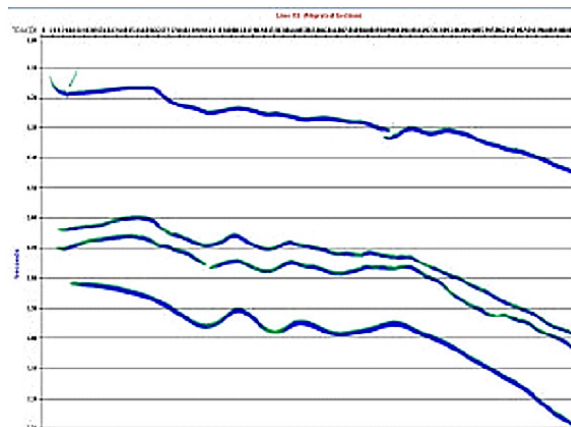


Fig. 3a PP section for Line 01

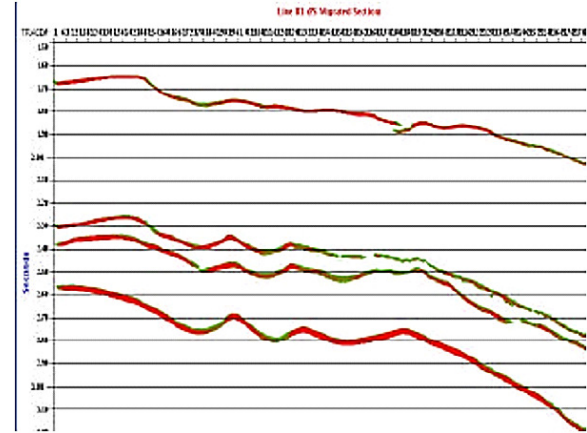


Fig. 3b PS section for Line 01

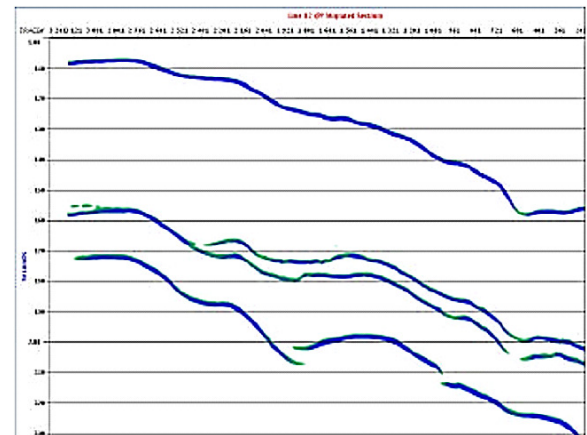


Fig. 4a PP section for Line 02

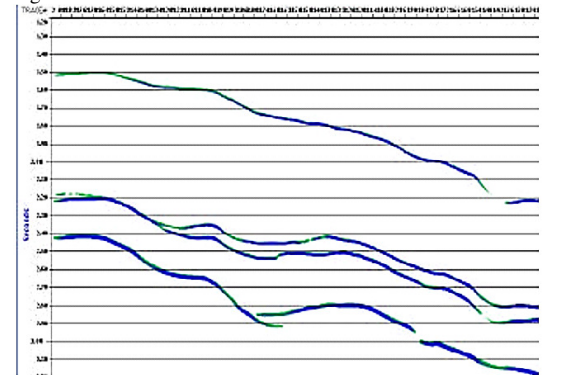


Fig. 4b PS section for Line 02



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It was observed that illumination of reflectors from both the lines were equally good. PP and PS signatures are clearly seen on both the lines. Thus acquisition parameters used in modeling are suitable for actual data acquisition. Synthetic PP data processed time are also compared to the time sections of the earlier 3D data (Fig. 5) in this area and found that they are almost tallying.

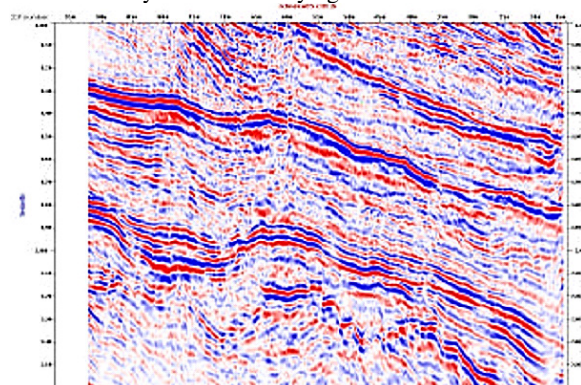


Fig. 5 Corresponding PP Section from 3D Volume

Actual field data was acquired in the direction of Line 02 as this is the geological dip direction and more drilled wells are falling along the line.

Acquisition Geometry

The desired line was shot with bearing of 115 deg. Acquisition parameters were kept as in modeling. The field recording parameters can be summarized in the following table.

Gr. Int	10 m	Far Offset	5000
Shot Int.	50 m	No. of Shots	343
Channels	1000	Data Line Length	17 km
Type	SSS	fold	100
Rec Length	8.0 sec	Rec Ins.	I/O Scorpion, Digital
Charge Size	5 kg	Shot depth	28-30 m

Table 1

Higher fold, small group interval, data record length ~ 1.6 times of P-wave data length and other acquisition parameters were given due consideration for getting good quality data as per the requirements of PS mode acquisition as described by Garotta and Granger (2003).

The perpendicular offset for most of the shots was very high as mentioned in the following table due to logistic problem.

Offset (m)	No. of SP
0-10	93
10-25	63
25-50	50
50-100	52
100-125	23
125-150	14
150-175	2
175-200	0
Skips	45
Total	343

Table 2

Processing of PP and PS data

The SPS data was merged with seismic data and QC was carried out to check the correctness of coordinates supplied by the acquisition crew. Two horizontal components (X & Y) and one vertical component (Z) data were separated to form 03 types of datasets viz. X, Y and Z. The vertical component data was processed by adopting normal processing sequence. Residual static applied stack section and post stack migrated section were prepared as final outputs as shown in Fig. 6 & Fig. 7.

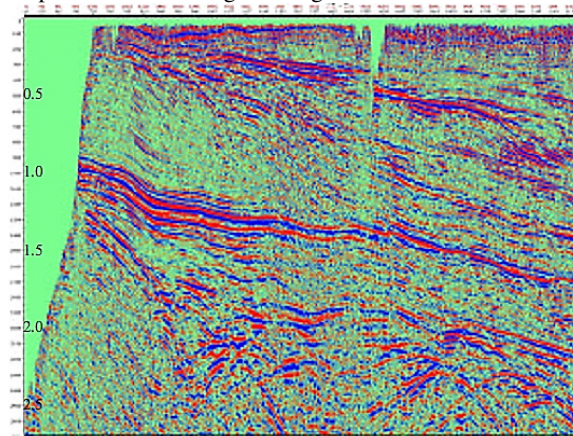


Fig. 6 PP Stack Section



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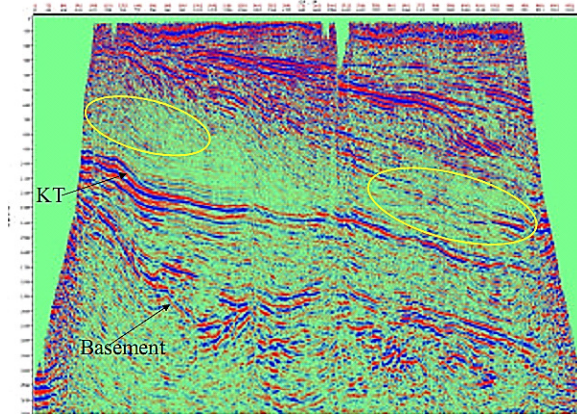


Fig. 7 PP Migrated Section

Processing of PS data started with making the common manual edit files for X and Y shots for editing purposes. This gives the equal no. of traces for X and Y data sets used for rotation for getting Radial (R) and Transverse (T) component data sets. Rotation was required for this 2D line data set as inline offsets were very high as shown in Table 2. The Radial data set (R) has improved after rotation as shown in Fig. 8.

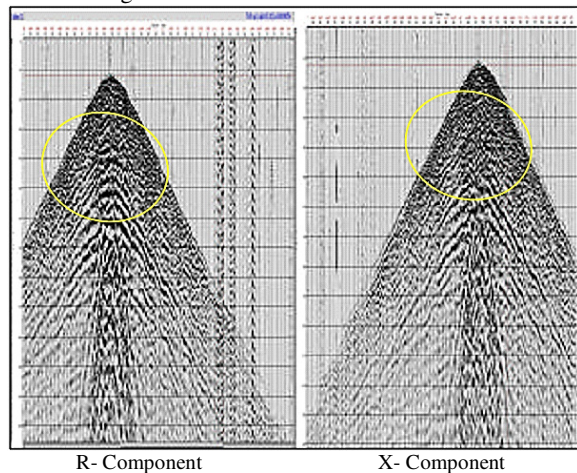


Fig. 8 Improvement of signal after rotation

After rotation it was found that most of PS reflection energy is concentrated on the radial component as shown in Fig. 9. Thus, T component data was not processed. This data behavior confirms that the area of study does not have much anisotropic layering. Of course this conclusion is

valid for the area covered by the 2D line and final conclusion can be derived only with wide azimuth 3D3C data.

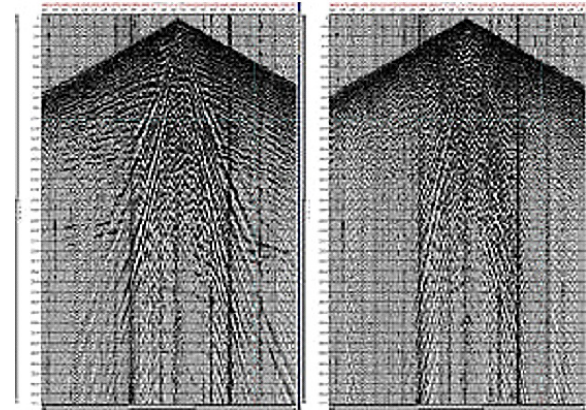


Fig. 9 Radial & Transverse components

Another important step in processing of PS data was to derive shear wave receiver static. The static values were calculated using the static tool of Vector-Vista processing package. Field shot static correction was applied before receiver static calculation. The effectiveness of receiver static application can be seen by comparing the receiver stack sections before and after receiver static application as has been shown in Fig. 10. Left over residual static problem was solved by the application of four iterations of residual static corrections.

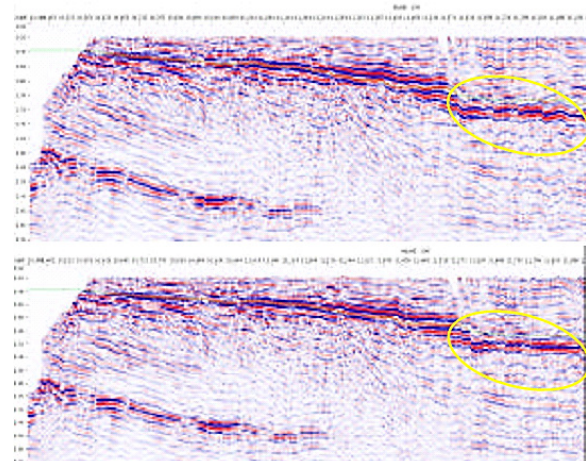


Fig. 10 Receiver stack section before & after Receiver Static correction



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Final stack section for PS data is shown in Fig. 11. Migration module was not successful on PS data due to poor S/N ratio of the data especially at basement level.

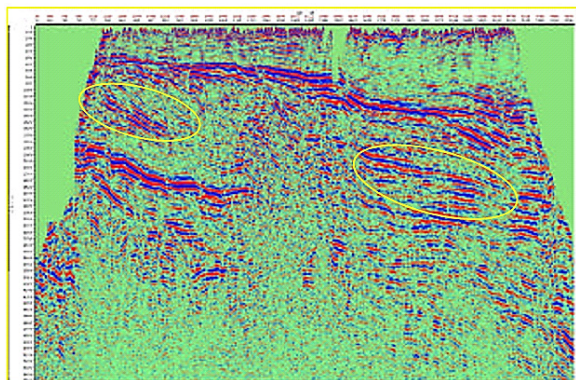


Fig. 11 PS Stack Section

Thus application of time and space variant gamma values was not possible and section was processed (binned) with single gamma value which was more appropriate at the level of KT marker level (TWT of 1.8 sec) for which it was derived.

Observation on Final processed output

The marker events corresponding to PP section are seen in PS section except basement. Basement event is seen in patches. Also KT marker is very poor in the middle of the section. This may be due to very low S/N ratio of input data as observed on raw data. PS section (Fig. 8) has better imaging at certain places as marked than PP section (Fig. 7). These better imaging areas can be attributed to hydrocarbon pay zones. PP and PS section in PP time are put together in Fig. 12 for comparison purpose.

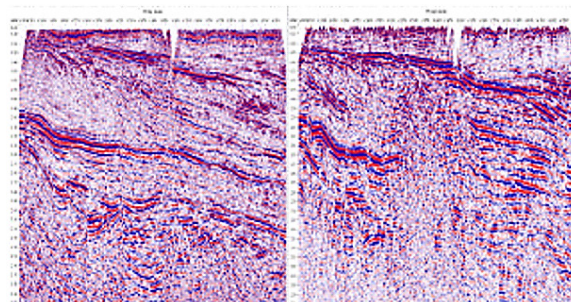


Fig. 12 PP & PS (in PP time) sections

Conclusion

PS section can help in mapping of hydrocarbon pay zone horizons more precisely as imaging has improved in these regions. The improvement in data processing was limited due to 2D constrains and poor S/N ratio of the data as far as PS data is concerned.

3D3C data will certainly give better picture of subsurface where data will be improved at the stage of 3D migration using time and space variant gamma values. Azimuthal anisotropy studies can also be carried out with 3D3C data set.

References

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