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Analysis of Vs, Vp/Vs & Poisson's ratio from Rig Source deviated VSP vis-a-vis Log data -A case study

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Summary

In rig source deviated VSP the horizontal components (H1 & H2) contain some coherent energy. There is P to S conversion of energy. The horizontal components (H1 & H2) are used to compute maximum energy in the horizontal by using polarisation technique. The shear down going event is picked in the raw data, then refined in the horizontal maximum component. Then Vp/Vs, Poisson's ratio and cross plots are generated from VSP and compared with that of log data recorded in the well. There is good match between the two along the well column and is corroborated in the gas bearing zone.

Keywords: Rig source deviated VSP v/s log data

Introduction

Different VSP configurations are in practice in the industry like rig source VSP, rig source deviated VSP, vertical incidence deviated VSP, walk away VSP and far- offset VSP. In case of rig source deviated VSP survey, the source is placed near (zero offset) the well head and the well trajectory is deviated. As a result, wave fronts are incident on the formation boundaries at non-normal angles of incidence and generate converted waves. Converted wave surveys use conventional P-wave sources and three component geophone. In VSP, the most common mode conversion in the source-receiver vertical plane is, from compressional P-wave to shear wave or SV-wave.

It is a known fact that S velocity can be computed from 3 component VSP data set, but in many wells we do not have dipole sonic to crosscheck S velocity from VSP. The question arises what is the accuracy and the confidence level of S velocity derived from VSP?

As surface seismic data becomes more and more - complex (9C-3D), a lot of multi component data is being acquired, processed and interpreted in many areas, VSP can be useful in providing shear wave propagation velocity in the area at well location which can be useful in processing of 3-C seismic data and can give greater confidence in multi component processing.

In many three component VSP data sets, mode converted waves are observed in the horizontal components which can be enhanced through polarisation method and can be picked with confidence. A number of old VSP datasets are available which can be revisited for mode converted energy in the horizontal components.

In this paper, rig source deviated VSP of a well dataset is considered where S wave log & Poisson's ratio log are recorded. Here a case study of a zero offset deviated VSP survey conducted in a well of Western offshore basin, in Western India is presented where an attempt has been made to generate S velocity from horizontal component. Vp/Vs and Poisson's ratio are computed. A comparative study is made between shear velocity, Vp/Vs and Poisson's ratio derived from VSP and recorded well log data.

Geology

The study area falls in the Tapti-Daman area in the western Offshore Basin (Fig.1).

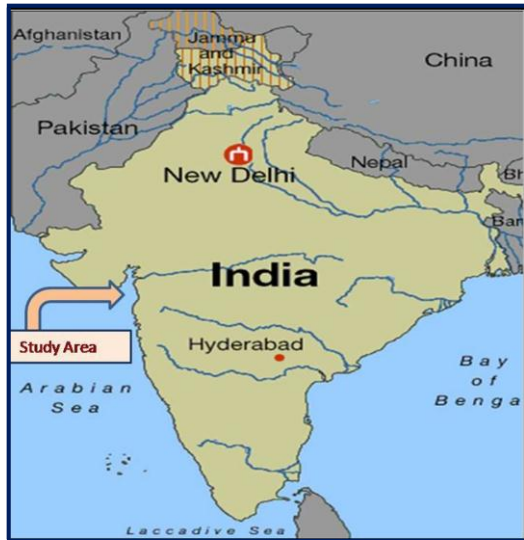


Fig.1 Location map of the area

The structural, strati-graphic as well as combination entrapment conditions are observed in the area for reservoirs of Daman and Mahuva formations of Oligo-Miocene age. In Daman formation, the deltaic fringe sands and distributary channel sandstones form the main reservoir pays. These sands are multi-layered with intervening shales.

Data Acquisition

A three component VSP survey was conducted in the deviated well (maximum deviation 25.8 m @2332.69m KB) with source offset 40m and Azimuth 80 Deg. Two gun cluster with Soder G-Gun was used with 2000 psi gun pressure. The tool used was Geophone Accelerometer (GAC), Tri Axial. The survey was conducted for 152 levels between depths of 352 m -2636.0m with 15m receiver interval.

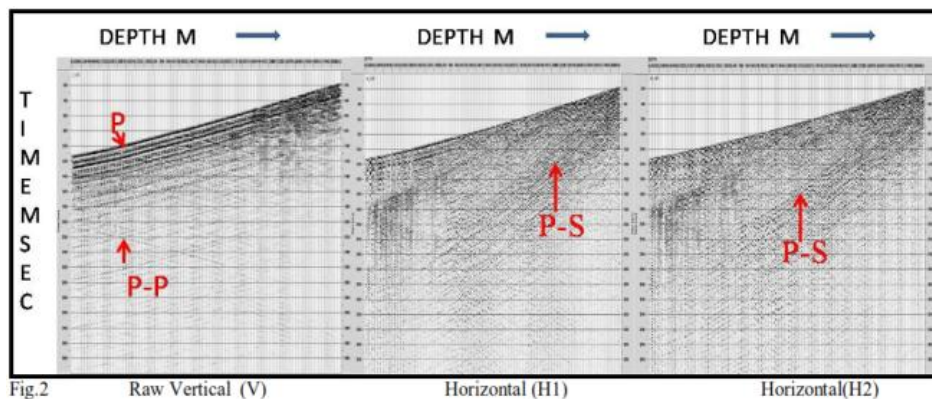
Data Analysis

Fig.2 shows the all the three components of raw data recorded. Z is the vertical component of the wave field and H1 and H2 are two horizontal components. Strong down going P-wave direct arrival (event P) and up going P-wave reflections (event P-P) are annotated. Converted P-S down going (event P-S) are seen in the raw horizontal components. Such events are used for computation of S velocity.

Methodology

Following flow is used to process the data. The horizontal components (H1 & H2) contain a lot of coherent energy and are used in the processing to utilise the total energy available. The horizontal components (H1 & H2) were used to compute maximum energy in the horizontal by using polarisation technique. The H1 & H2 components were projected at each level individually along (HS) and perpendicular to the direction of maximum energy (HT) in the source-well plane Input for the processing is raw gathers (V, H1 & H2 components.)

- Pre processing (geometry merging, pre filter, editing, first break picking)
- Picking of shear wave event on the of H1 & H2
- 3-Axis Polarisation and projection of H1 & H2 components along and perpendicular to the direction of maximum energy in source-well plane(Fig.3) and then refining of the picking.





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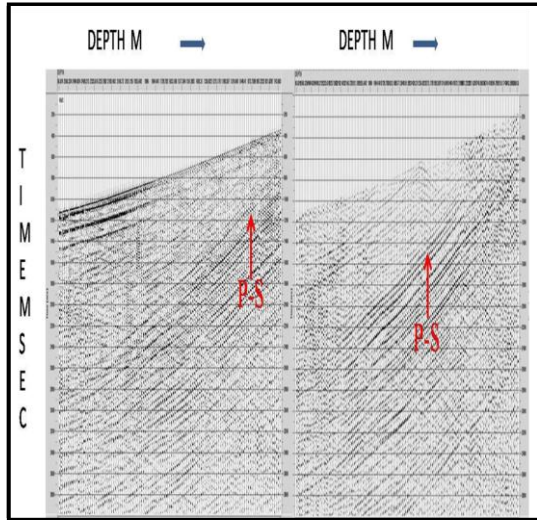


Fig.3 Maximised comp. (HS) Transverse Comp.(HT)

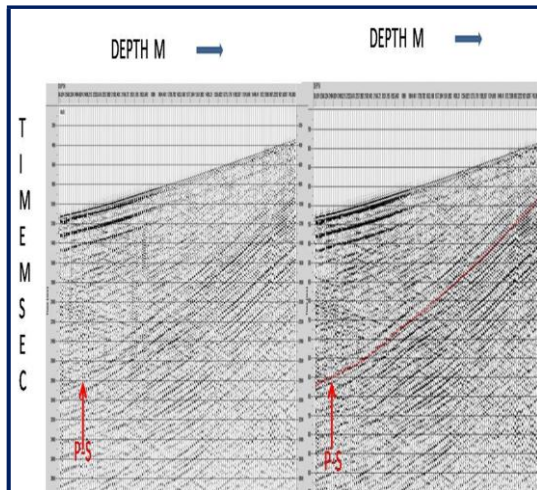


Fig.-4 Maximised component(HS) With S-event Picking

Study of V_p/V_s & Poisson's ratio with log:

Shear wave event is picked in the raw horizontal component and then refined in the maximised horizontal component (Fig.4).

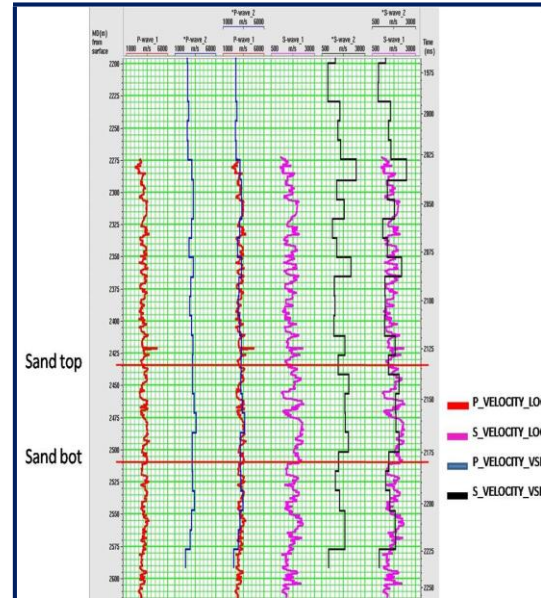


Fig.5 Velocity (VSP and Logs)

Then interval velocity is computed which is compared with that of Log (Fig. 5). V_p/V_s is derived from VSP data and studied with respect to log data (Fig.6). Poisson's ratio is calculated from VSP data and is plotted along with recorded Poisson's ratio (Fig. 7).

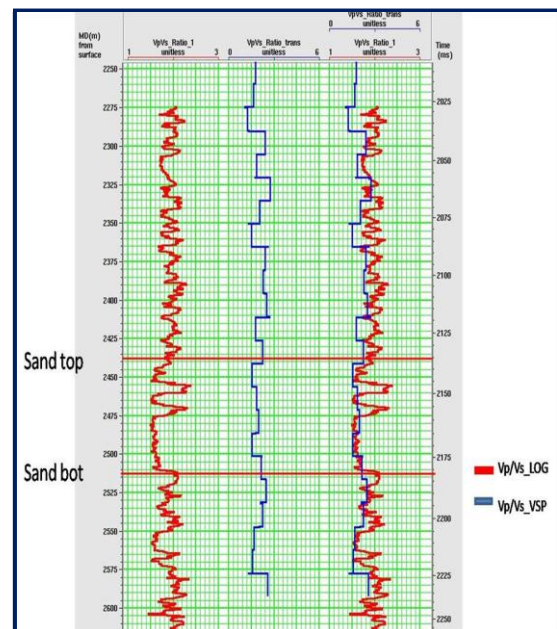


Fig.6 V_p/V_s (VSP and Logs)

Cross plots of DT (transit time) v/s V_p/V_s for both VSP and



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recorded logs are generated and studied (Fig.8). Cross plots of Poisson's ratio with respect to DT are plotted to see the behaviour of the gas sand at target zone (Fig.9).

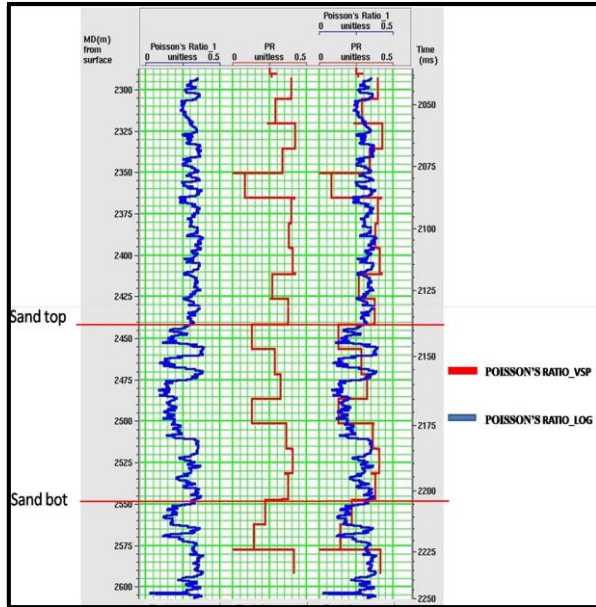


Fig.7 Poisson's Ratio (VSP and Logs)

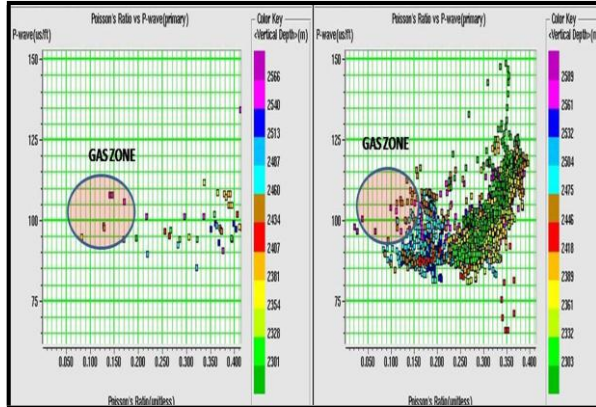


Fig.8: Cross plot Vp/Vs v/s DT (VSP and Logs)

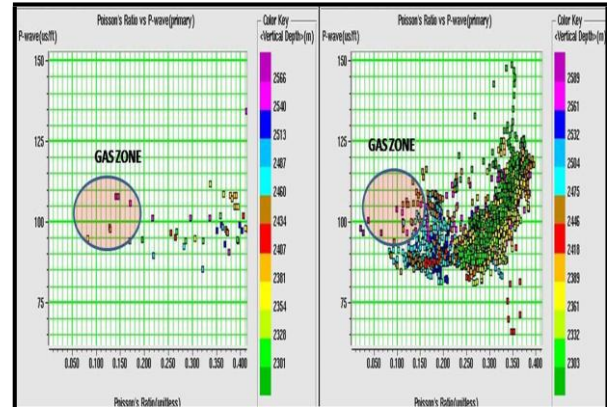


Fig.9 Cross plot Poisson's Ratio v/s DT (VSP and Logs)

Conclusion

- There is reasonably good match between VSP log and recorded log data. Due to lesser depth sampling interval of VSP compared to sonic log the values of elastic parameters like Vp/Vs and Poisson's ratio in the reservoir zone is averaged out as compared to the log. But the increasing S- velocity trend is observed indicating the gas bearing zone.
- The VSP data suffers from the limitation of lesser sampling interval compared to the log data. Therefore, depth sampling in the target zone should be more dense during VSP data acquisition.
- In cases where shear wave log data is not available, the VSP derived shear log may be a valuable tool for the interpreter to infer about the probable gas bearing zones.
- Shear wave interval velocities computed from VSP can be utilized for migration, trace amplitude inversion and depth conversion for multi- component surface seismic data.



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