



Reprocessing of 3D seismic data pertaining to KD-3D block for imaging Mesozoic sequences and Intrusive

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Keywords

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Summary

Interpretation of 3D seismic data in KD-3D block has been largely handicapped due to the poor data quality. This article describes a reprocessing sequence of seismic data for improving imaging of Mesozoic sequences and igneous intrusive body. The area has shallow and relatively hard seafloor and Mesozoic sediment are covered by flood basalt. Conventional techniques such as Tau-P decon fails to remove surface multiples generated by seafloor. Surface related multiples elimination (SRME) cannot work due to lack of proper water bottom reflection energy even at near offset. Parabolic radon transform (PRT) is difficult to run due to uncertainty of primary velocity trend. On the other hand Tau-P hyperbolic velocity filtering (HVF) technique is highly capable to attenuate surface related multiples for such a complex scenario and helps to pick primary velocity with confidence. As a result, there is a significant improvement in imaging below the basalt.

Introduction

The present study area lies in Kutch Saurashtra basin, situated off West coast of India (Figure: 1). Huge hydrocarbon has been prognosticated in Mesozoic sequences. Here, petroleum system established Mesozoic-Mesozoic and Mesozoic-Tertiary. However, Mesozoic sediments are highly disturbed during KT boundary and subsequently covered by thick flood basalt. The area is also been impregnated by lot of intrusive activity. It is reported from Faroe-Shetland Basin, magmatic intrusions acts as both as barriers and/or carrier guide for fluid flow/hydrocarbon migration. The intrusive/fractured dolerite also acts as a reservoir. Within the Ayukawa oil field in Japan, main reservoir is formed from dolerite. Also, one well in adjacent Block of the present study area is producing hydrocarbon from

fractured dolerite reservoir (in Mesozoic section) at the rate of 2.62 lac per day through 1/2" choke.

So, proper imaging of Mesozoic section and intrusive bodies are essential to understand the syn-rift geometry of the Basin, hydrocarbon migration mechanism and also to unfold huge resource from Mesozoic section. To full fill this objective, reprocessing job was undertaken.

The water depth in this area varies from 7m to 20m. In this area Mesozoic is covered by thick basalt. Strong mode conversion takes place at the top and bottom of the basalt. Severe scattering occurs at the top of the basalt. Due to presence of thin layer of sediments within the basalt, destructive interference also takes place. Moreover, there are strong carbonates present above the basalt. Due to these, penetration of primary energy through basalt is very weak. Also, the Mesozoic sequences are completely obscured by strong peg-leg multiples generated by carbonate, basalt and seafloor and also inter-bed multiples generated by carbonate and basalt. As primary energy is very weak below the basalt in comparison to strong multiples, hardly any semblance due to primary energy is observed below the basalt (as shown in figure No. 2).

Theory/Method

The 3D field data in this basin was acquired with a configuration of dual source and three cables. The cable length is 6 km with channel spacing of 12.5 m and the cable separation is 100 m. The source and streamers were towed at a depths of 5 m and 7 m respectively. The guns were fired at an interval of 25 m (flip flop) which results in a nominal fold of 60. The nearest channel at the central cable is 100m from the source. Since the seafloor depth in this region varies from 7 m to 20 m, the water bottom reflection is close to the critical angle.

The surface related multiple elimination (SRME) has been acknowledged as an effective data driven

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method. But, in this area, distance between source and streamer is significantly larger than the depth of seafloor. Reflection energy from seafloor is unable to reach even at near offset. So, SRME cannot model the water bottom correctly and fails to attenuate shallow water multiples. Generally, predictive deconvolution, either in T-X or more usually in Tau-P domain is used in such prospect for attenuating shallow water multiples. A hard seafloor can cause higher amplitude in multiples than in primary. In such cases, deconvolution cannot attenuate the multiples in totality and usually attacks primary events that have a periodicity close to that of the water layer. Even after application of deconvolution in Tau-P and T-X domain, multiple energy is not attenuated significantly as shown in figure no. 2, consequently, primary velocity trend is still missing. As primary velocity picking is not possible, Tau-P hyperbolic velocity filtering (HVF) is chosen for modeling multiple energy using RMS velocity of multiples. The HVF is the equivalent of a matrix process that is applied in the slant-stack domain. The Tau-P transform at an offset is muted along curves that are dependent on the specified multiple-velocity limits. The muting process is repeated for each offset. So, if RMS velocity of multiples energy is supplied, the HVF attenuates the multiples significantly from data set. It will be demonstrated, how it works in shallow water prospect where primary velocity trend is nearly invisible.

Therefore, instead of picking primary velocity, the velocity of multiples were picked and HVF was run with this velocity field with limiting range of -25% to 10%. After the application of HVF, primary velocity analysis was carried out. The final re-processing work flow is as given below:-

Read SEG-D
Navmerge
Debubble/Zero Phase filter
Spherical Divergence Correction
Trace Editing
Tau-P Decon
CDP Sorting
Decon in T-X Domain
Offset Regularization
Multiple Velocity Analysis
Hyperbolic Velocity Filter
Boosting of Low Frequency below Basalt
Primary Velocity Analysis

Target Line Migration
Updating RMS Velocity
Pre-Stack Kirchhoff Time Migration
Parabolic Radon transform
Trace Muting and Staking
De-noising and Gain Adjustment

Example

The semblance of one CDP gather before and after HVF are shown in figure: 2 & 3. From this figure, it is very much clear that how much effective this technique is to unfold the primary velocity trend below the basalt.

Earlier processed data of one inline and one cross line is shown with the present output in figure number 4,5 and 6,7 respectively for comparison. In earlier stack sections, Mesozoic sequences and geometry of intrusive below the basalt are not visible due to presence of strong multiples whereas, these are very prominent in the present reprocessed data. This outstanding improvement in Mesozoic sequences as well as intrusive is due to attenuating multiples and picking proper velocity trend.

In figure number 6, geometry of the intrusive is very much similar to producing intrusive at the adjacent block. So, this type of intrusive will be interesting from hydrocarbon point of view.

In figure number 7, the saucer-shaped sill is very much interesting in prospecting point of view as hydrocarbon is migrated along the rim of sill and accumulated above the tips of the sill as reported from Faroe-Shetland Basin (Dong E & P (UK) Ltd, London, School of Geophysics, University of Birmingham).

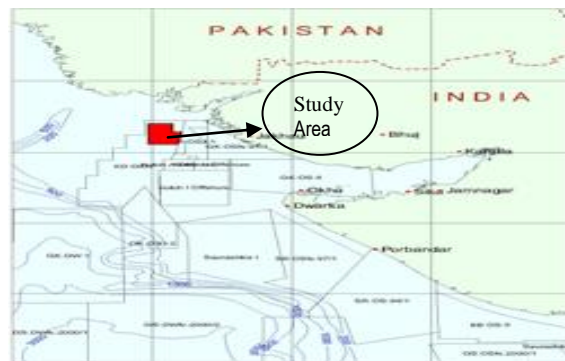


Figure 1: Location map

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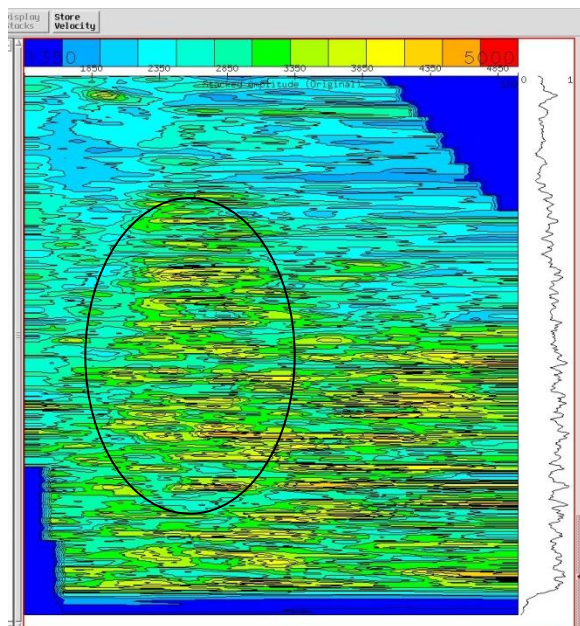


Figure: 2 Semblance after Tau-p decon (48ms)+T-X decon(24ms). Multiples are not attenuated significantly. Primary velocity trend is completely missing.

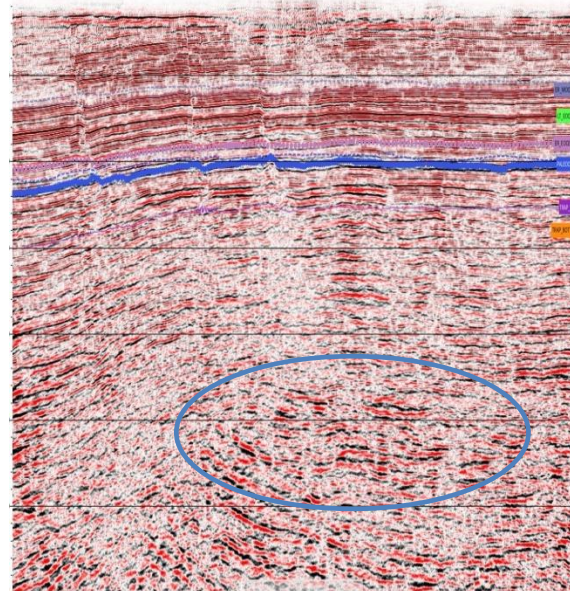


Figure: 4 Old Reprocessed PSTM Stack of one inline (Input to PSTM: taup-dcn:48ms+T-X decon:24ms+PRT). Mesozoic sequences and intrusive are not visible.

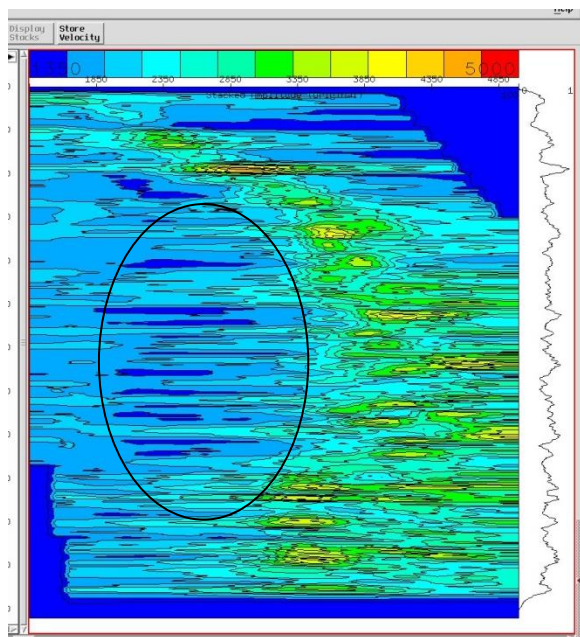


Figure:3 Semblance after HVF on the above cdp gather. Primary velocity trend has come out clearly. Primary velocity can be picked confidently.

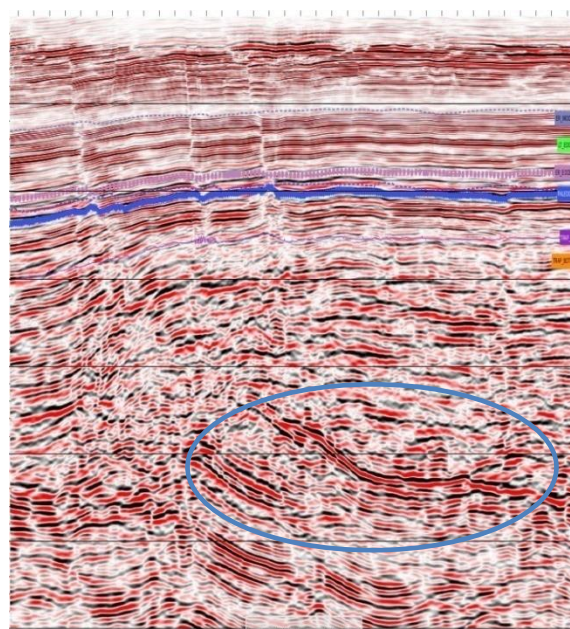


Figure: 5 Present PSTM Stack of the above line (Input to PSTM: taup-dcn:48ms+txdcn:24+HVF). Dramatic improvement in imaging in Mesozoic sequences and intrusive.

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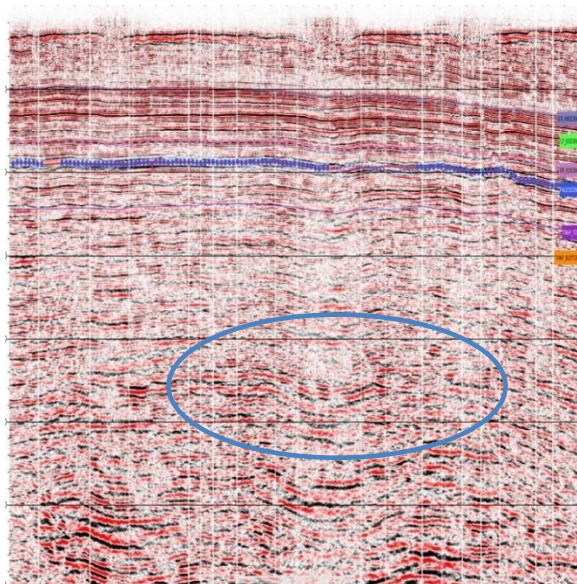


Figure: 6 Old reprocessed PSTMS tack of a cross line (Input to PSTM: $\text{taup-dcn:48ms+tx dcn: 24ms+PRT}$). Mesozoic sequences and intrusive are not clear.

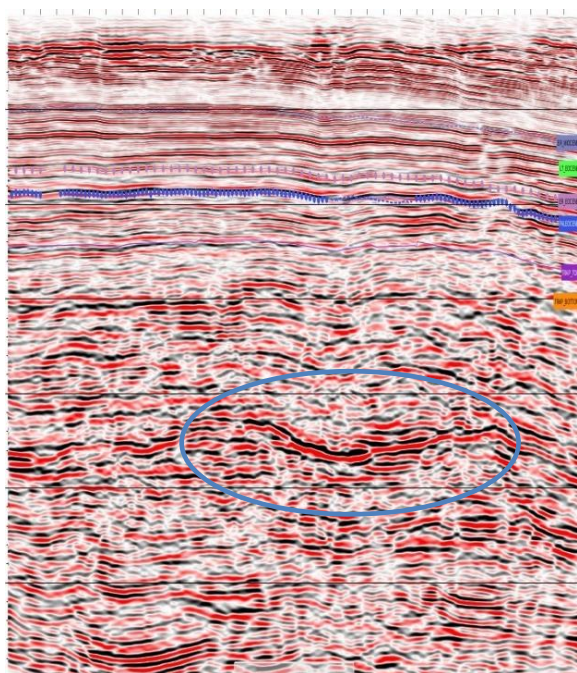


Figure:7 Present PSTM Stack of the above cross line (Input to PSTM: $\text{taup-dcn:48ms+txdcn:24+HVF}$). Outstanding improvement in Mesozoic section and also saucer shaped intrusive has come out brightly.

Conclusion:

For interpretation of hydrocarbon reservoirs in the shallow water areas like KS-3D area, one of the necessary seismic data processing steps is to effectively attenuate the multiples. It has been shown that traditional methods are not adequate in suppressing these multiples. Through the successful application of hyperbolic velocity filter in this project, it is recommended that this technique can be considered as one of the effective multiple attenuation methods in the processing workflow for the data acquired in such areas. This high quality 3D seismic data will help interpreters to understand the complex geometry of subsurface magma plumbing systems and also to generate new prospect in this area.

References

1. Brysk. H. and McGowan, D. W., 1986. A slant-stack procedure for point-source data. *Geophysics*, 51. 137 & 1386
2. Chapman, C. H., 1981, Generalised Radon transforms and slant stacks: *Geophysics. J. Roy Astr. Soc.*, 66, 445-453
3. Efficient tau-p hyperbolic velocity filtering, *Geophysics*, Vol. 55, No. 5, 1989, PP. 619-625.
4. Diebold. J. B., and Stoffa, P. L., 1981, The travel time equation, tau-p mapping and inversion of cmp data: *Geophysics*: 46, 238-254.
5. Kelamis, P.G. and A.R Mitchel. 1989, Slant stack processing, *First Break* 7:43-53
6. Kernett, BLN, 1979, the suppression of surface multiples on seismic records, *Geophysical prospecting*, vol. 27, pp. 584-600.
7. Remi Rateau, Michel Smith and Nick Schofield. The potential role of igneous intrusions on hydrocarbon migration, West of Shetland. *Petroleum Geoscience*, Vol. 19, 2013, pp. 259-272.

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