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Author **jyotirmoy kole , ONGC Ltd , India**
Co-Authors **Subhankar Basu, Sucheta Dhotiwala**

Structural improvement under Basalt in Kutch Saurashtra offshore basin using joint application of Hyperbolic Velocity Filter and Parabolic Radon Transform

Abstract

This paper describes a methodology of reprocessing of 3D seismic data that was acquired in Kutch Saurashtra offshore basin for Mesozoic as a target. This area has shallow and relatively hard seafloor. The Mesozoic's below the basalt are completely masked by surface and inter-bed multiples. Conventional techniques such as Tau-P decon, SRME and Parabolic Radon Transform fail to remove these multiples. Parabolic radon transform (PRT) is difficult to run directly due to uncertainty of primary velocity trend due to presence of strong multiples energy below Basalt. In this paper, we will show how hyperbolic velocity filter and parabolic radon can change the structure below the basalt.

Introduction

Kutch Saurashtra basin is situated in the Arabian sea, West coast of India (Figure No. 1). The water depth in this area varies from 10 m to 20 m. Here, the seafloor is very hard. The Mesozoic's of this region are believed to be a potential source of hydrocarbon. Unfortunately, Mesozoic's are highly disturbed during KT boundary and subsequently covered by flood 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 takes place. Moreover, there are strong carbonates present above the basalt. Due to these, penetration of primary energy is very much weak below the basalt. Also, the Mesozoic's are completely obscured by strong water bottom, interbed and peg-leg multiples generated by carbonate, basalt and seafloor. Consequently, no primary velocity trend is observed below the basalt. In earlier processing, the data was preconditioned using Fx-decon, Taup-decon and Parabolic Radon transform and migrated using Kirchhoff Pre Stack Time Migration. As usual there was no imaging problem in tertiary level but failed to image Mesozoic structure. After details study, we found that improper velocity field was the main cause of failure in earlier study.

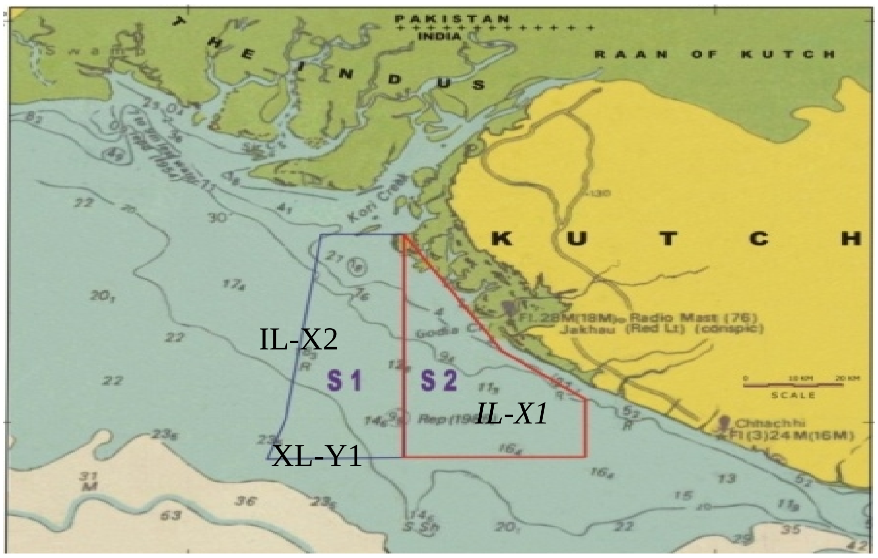

Figure 1: Location map

Method

The 3D field data in this basin was acquired with a configuration of dual source and three cables. The cable length is 5 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 50. The nearest channel at the central cable is 100 m from the source. Since the seafloor depth in this region varies from 10 m to 20 m, the angle of water bottom reflection is close to the critical angle.

The surface related multiple elimination (SRME) has been acknowledged as an effective data driven method. But, in this area, distance between source and streamer is significantly larger than the depth of seafloor. Reflection energy from seafloor cannot reach even at near offset. So, SRME cannot model the water bottom correctly and failed 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 fully the multiples and usually attacks primary events that have a periodicity close to that of the water layer. Even after application of Tau-P deconvolution, multiple energy is so strong that primary velocity trend is invisible as shown in fig: 2. So, parabolic radon cannot be applied directly.

From figure: 2, it is very much clear that primary velocity picking is not possible but multiple velocity can be picked with confidence. So, we picked velocity of multiple energy instead of primary energy. With this velocity, we run Hyperbolic Velocity filtering (HVF) to attenuate multiple energy. Now, we picked the primary velocity confidently from semblance of the HVF applied gather (as shown in Figure 3). Now, we run PSTM with this velocity field. Then we run PRT on the migrated gather to attenuate remaining multiples. Finally we stacked PRT applied migrated gather after proper front mute. In the earlier processing the PRT was also run before and after migration and stacked the PRT applied migrated gather after inner and outer mute. But, earlier technique failed to image below basalt due to improper velocity field. At the present study, there is a dramatic structural improvement in Mesozoic's level due to proper velocity field and proper handling of multiples.

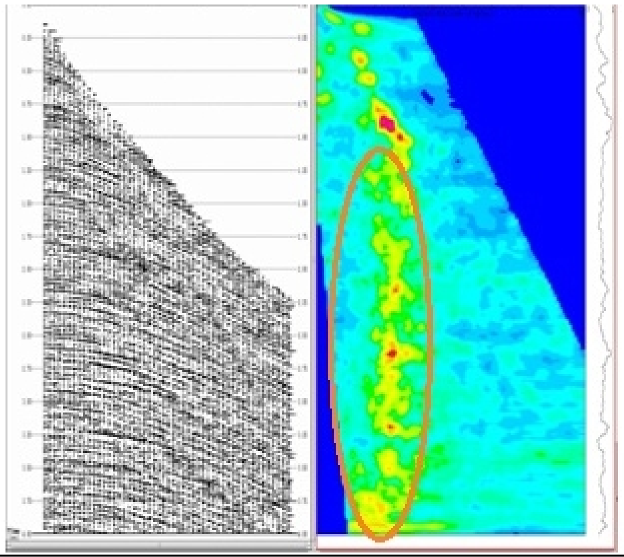

Figure: 2 Semblance before HVF (primary velocity trend is not observed due to presence of strong multiple energy)

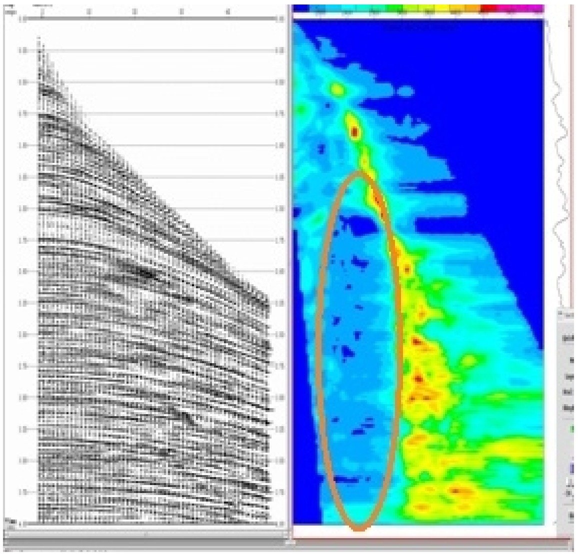

Figure: 3 Semblance after HVF on the above cdp gathers (primary velocity trend has come out nicely)

Discussion:

We had taken two in lines (SE-NW direction) and one cross line (NE-SW direction) for the present study (as shown in Figure no. 1). We had taken old taup-dcn gathers (without PRT applied) for the present study. The final new PreSTM stacks of the three lines are compared with the corresponding old PreSTM Stacks section (as shown in Figure no. 4 to 9).

In earlier stack sections, Mesozoic structures below the basalt are not properly visible due to presence of strong multiples whereas, in the present section Mesozoic structures have come out nicely. This big change is due to proper velocity field and attenuation of multiples properly.

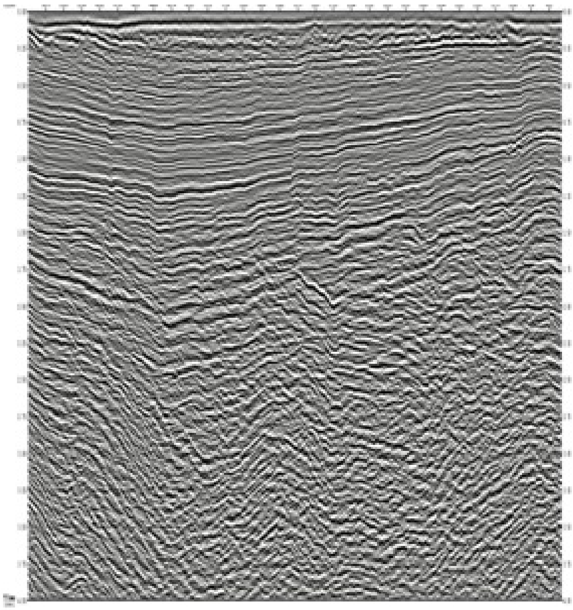

Figure:4 IL:X1 Old PreSTM Stack (Mesozoic's structure is completely masked by multiple energy)

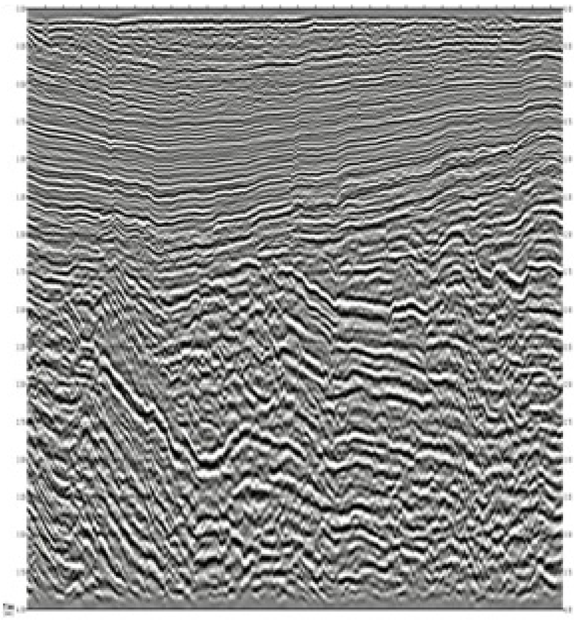

Figure: 5 IL: X1 Reprocessed PreSTM Stack (Mesozoic's structure has come out nicely after attenuating multiples)

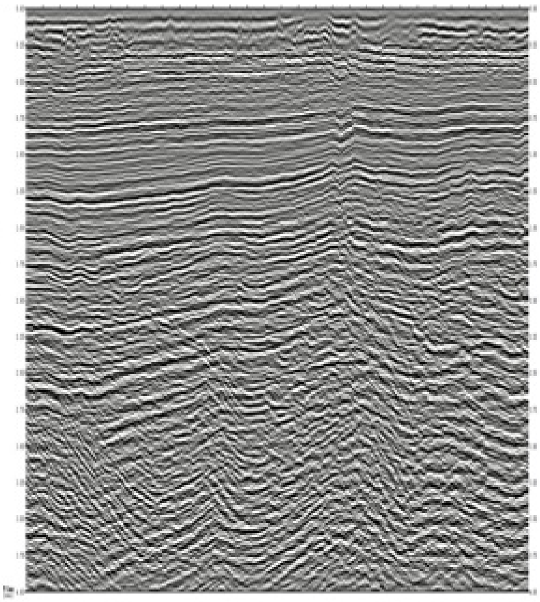

Figure:6 IL:X2 Old PreSTM Stack (Mesozoics structure is completely masked by multiple energy)

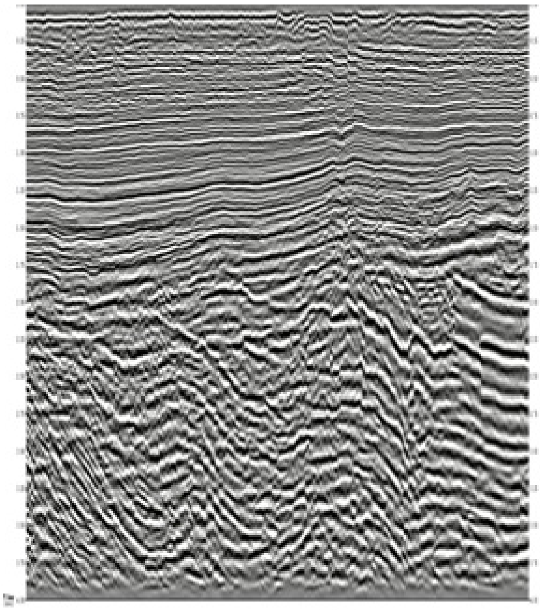

Figure: 7 IL: X2 Reprocessed PreSTM Stack (Mesozoic's structure has come out nicely after attenuating multiples)

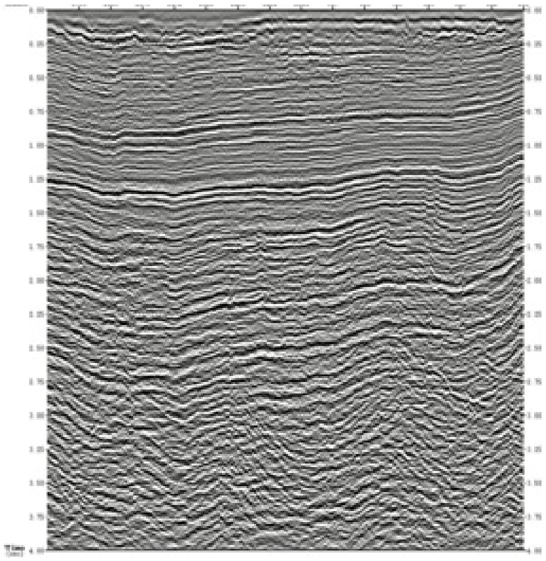

Figure: 8 XL:Y1 Old PreSTM Stack (Mesozoics structure is completely masked by multiple energy)

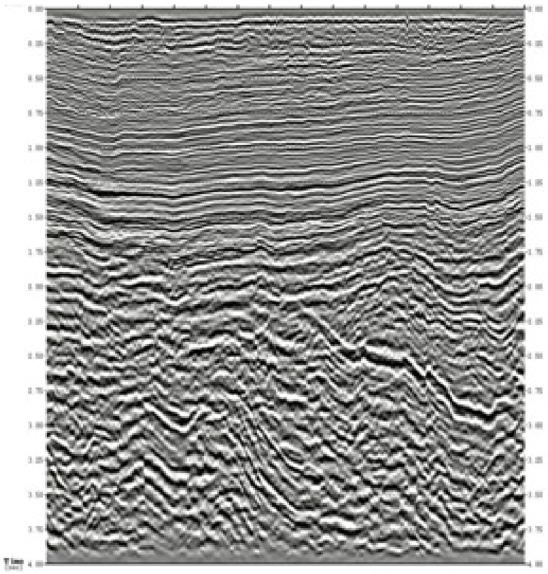

Figure:9 XL: Y1 Reprocessed PreSTM Stack (Mesozoics structure has come out nicely after attenuating multiple energy)

Conclusion

For interpretation of hydrocarbon reservoirs in the shallow water areas like Kutch Saurashtra, 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.

The successful application of hyperbolic velocity filter before migration and PRT after migration may be consider as one of the effective multiple attenuation methods in the processing workflow for sub-basalt imaging.

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