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Preprocessing, A Keystep for Improved Imaging -An Example from Cambay Basin

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Summary:

This paper deals with improved imaging below Kalol which has been a challenge for the processors involved in data processing of Cambay Basin till date. The 3D seismic data acquired in Wamaj low area of Cambay Basin, India by the departmental crews of ONGC for the exploration of Basin centre gas accumulation in the year 2005-06 has been re-processed. Prior to this attempt, data has been processed twice for basic processing and subsequently pre-stack time migration. Interpreters, however, felt difficulty in mapping the deeper horizons e.g. YCS, OCS & Olpad formations below Kalol resulting in not meeting the objective of exploration of deep gas in this depression of the basin. The area is well known for the multiple of Kalol masking these deeper horizons as well as poor penetration of energy due to attenuation of high frequency from the coal seams. In order to make a meaningful Interpretation below Kalol a need was felt to re-process the data once more with special emphasis to image below Kalol

With the outputs of previous attempts of processing and interactions with the interpreter, it was amply clear that conditioning of the data / noise removal prior to pre-stack time migration has the scope for improvement in getting better image. Also an alternative to attenuate the Kalol multiple which has been identified as having low velocity gradient in this area and as such difficult to attenuate. Interference of ground roll frequency into useful low frequency band required for bringing out reflections from deeper horizons was another problem. Heavy industries, populated areas and highways were also responsible for poor S/N ratio of many traces. The need for thorough QC was also felt necessary at different stages of processing. Keeping these aspects in mind the data was taken up for conditioning with special emphasis on noise attenuation and suppression of Kalol multiple in parallel with two different softwares available at the centre. The results obtained with two softwares in suppressing the noises/multiples energy and bringing out deeper reflection were visibly different.

Further processing therefore was carried out with the software that provided better result and it superiored with those used in previous attempts of processing. The processing steps involved judicious killing of bad traces, suppressing of low velocity and low frequency energy of ground roll and cautious design of radon filter in attenuation of Kalol's multiple resulted in better conditioning of data. The problem of near surface velocity variation has been addressed with proper calculation of residual statics and its application. The improvement in data quality is obviously seen at every stage while doing QC. Initial results obtained with pre-conditioning of the data were very encouraging. The suppression of Kalol multiples and bringing out the deeper horizons is a milestone in the exploration history of Basin. With the analysis of results obtained in three attempts of processing the present work seems to fulfil the requirements of the interpreter.. It is also hoped that this attempt will pave the way of successful exploration of BCG as well as obtaining multiple free data in the Cambay Basin without affecting deeper reflections.

ED-HOI, KDMIPE, ONGC, DEHRADUN

Introduction

Pre-stack time imaging has become routine processing step in processing industry. The successful application of PSTM requires noise free input data and therefore conditioning of the data to make it noise free is essential. Apart from cultural noise, ground roll and multiple energy are the prominent source of noise in land data. The cultural noise in general affect a limited number but full trace and have frequency range within useful frequency range of seismic data. Therefore processor has no other option but to kill the whole trace. Ground roll and multiple energy affect a large number but part of traces. Processor cannot afford to kill so many of these traces but to remove the noise from affected part of these traces. Ground roll are low frequency low velocity but high amplitude noise which may be suppressed with low cut filter if they have frequency range below the useful frequency range. A number of modules are also available in different softwares for suppressing them. The availability of various modules and their way of implementation play a crucial role in success of noises removal and it varies from software to software.

The attenuation of multiples has been a high priority in marine seismic data in seismic industry due to presence of high impedance contrast from top and bottom of water column. Presence of a high impedance layer in land data may also pose the similar problem and it becomes acute when the multiples fall in the zone of interest. Strong multiple of Kalol Formation in Cambay basin hides the poor energy from the reflectors of YCS, OCS and Olpad formations resulting in poor/uncertain mapping. The scattering of the energy from the coals seams within Kalol formation decrease penetration of the energy down below. The low velocity gradient in the area decreases the effectivity of the multiple removal algorithm based on residual moveout which further aggravates the problem of imaging these deeper horizons. The diversity of multiple attenuation methods available in the industry are based on two differentiating properties – moveout and predictability. Methods are also now available which are based on modeling of the multiples (model derived from the data itself) and their adaptive subtraction. The radon filter based on moveout properties of the multiple has been used in the present work.

The Study Area

Exploration for deep-gas in deep sedimentary basins has acquired importance worldwide as a frontier energy source. Wamaj depression in Ahmedabad Block of Cambay Basin is identified as one of the deep sedimentary depression for detail study on the potentiality of deep gas or basin centered gas (Fig. -1). It has fair to good source rock potential and has good amount of Synrift fill deposits which has poor reservoir properties. Presence of gas (C1) during drilling of Olpad section in one well can be considered as positive evidence in support of generation of deep gas in the deeper part of the low. Olpad formation in Wamaj Low has generated around 2900 BCM of gas, which is maximum amount of gas generated in any of the lows in Cambay Basin for Olpad Formation (Rajeev Mohan et.al., 2006).

Deccan trap of Cretaceous age forms the basement of overlying sedimentary column. Olpad Formation of the block consists of trap wash and overlies the Deccan trap. Unconformably, it is overlain by Cambay shale (Lower Eocene) having producing sands also. This is overlain by Kalol Formation (Middle Eocene) which is a strong marker in the entire Cambay Basin. Kalol Formation is overlain by a shale sequence of Upper Eocene age and acts as good cap rock. Kalol Formation has been a major producer of hydrocarbons in the area but with the discovery of oil/gas within Cambay shale and Olpad Formations in some parts of the basin, interest has gained momentum for the exploration of hydrocarbons in the prospects below Kalol. But the proper imaging of those deeper Formations (Cambay and Olpad) had been a major problem due to energy attenuation from coal seams within Kalol Formation and multiples from good reflector near Top Kalol Formation.

Processing Effort

3D seismic data was acquired in this part of the Basin with the objective of exploration for Basin centered Gas accumulation. The orthogonal geometry with fairly good amount of explosive as energy source was used in acquiring the data with ***24*** bit delta-sigma technology recording equipment. The acquired data quality is fair to good but affected by the near surface problem of lack of proper shooting medium and cultural noise due to villages, towns, industries and highways in this area. The data seemed to have contamination with severe ground roll. The imaging of formations below Kalol and obtaining the continuity of reflections was challenging task. The data has been processed twice to obtain the desired objective with pre-stack time migration. However, results obtained were not optimum due to inadequate conditioning of the data prior to pre-stack time migration. The suppression of strong ground rolls whose frequencies were infringing into useful low frequency bands and multiples from Kalol which is difficult to be eliminated due to low velocity gradient in the area were two major hurdles in the conditioning. With the lessons and experiences of the processors of earlier attempts, data was taken up for the conditioning before pre-stack time migration at the centre. The different processing steps taken are as follows:

The editing of bad/noisy traces undertaken in two steps. Noisy traces and spike/noise bursts across the data volume were removed by auto editing module. The remnant noisy traces were manually edited. (Fig.-2, 3)

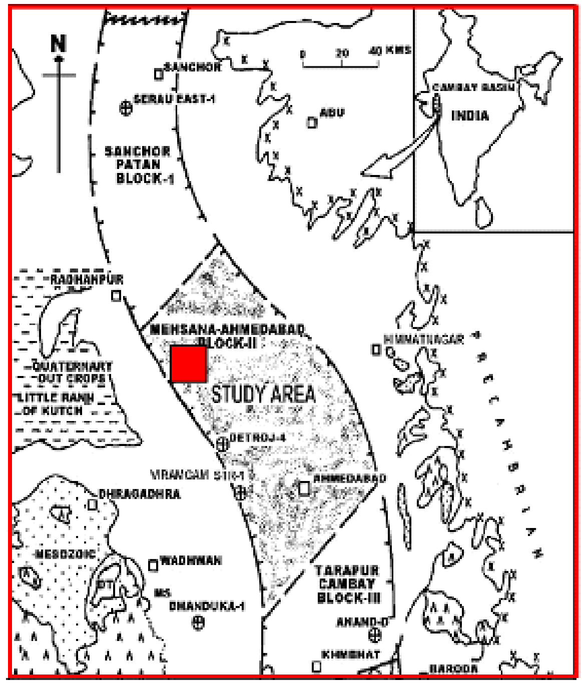

Fig 1: Study area in Cambay Basin

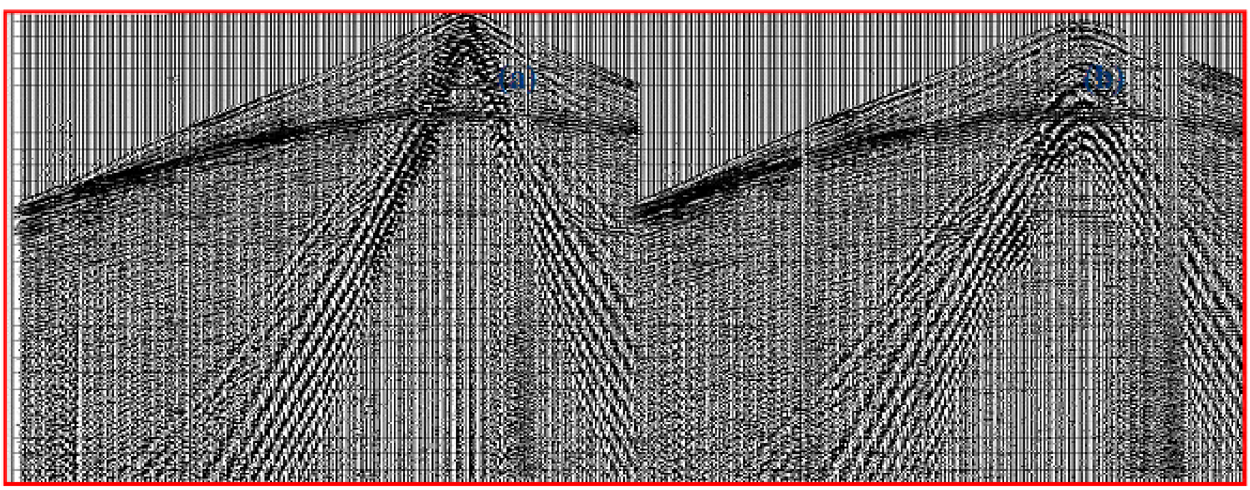

Fig.-2 Raw shot gather

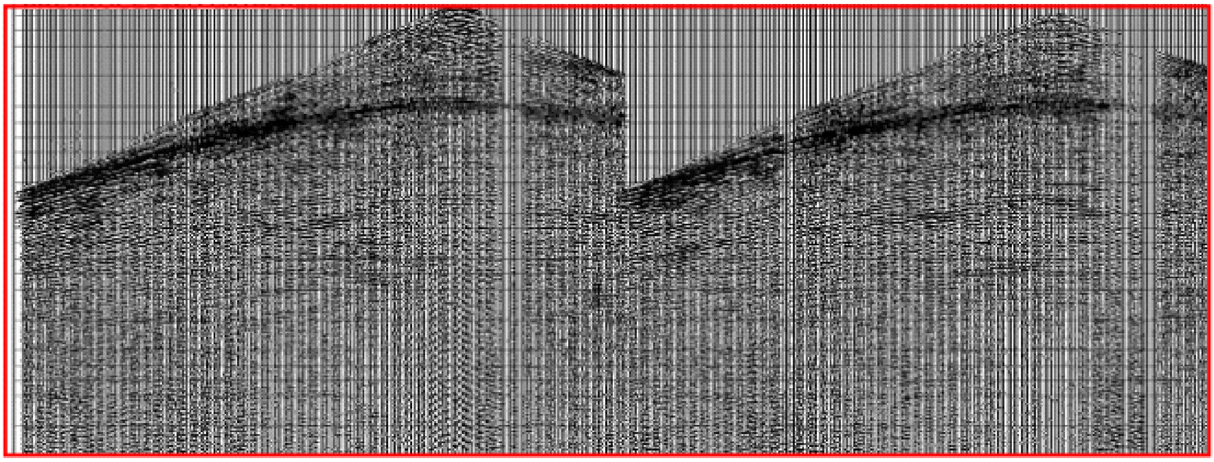

Fig.-3 Conditioned shot gather. Most of the surface noise has been eliminated.

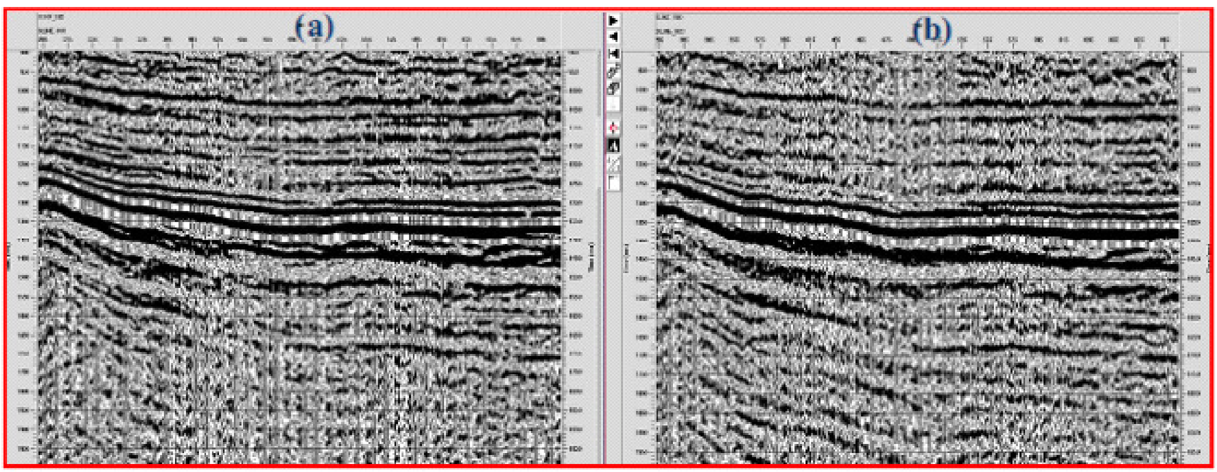

Fig. 4 Comparison of decon (b) & residual (a) stack. Residual statics application has enhanced the amplitude and continuity of the events.
(a)

Three prominent Surface noise trends were identified whose characteristics varied on different receiver lines and were attacked independently with appropriate parameters for effective elimination. The S/N ratio thereafter improved considerably which can be seen in the data. Near surface velocity variations in the area is well known hence the residual statics is supposed to enhance the data quality. Two passes of correlation residual statics has brought out continuity and resolution of reflections well (Fig.-4a). As has already been discussed and seen from the previous efforts that strong multiple activity generated from the Coal seams had been the biggest hinderance in bringing out the information from the deeper horizons. Hence a meticulous picking of Radon mute had been the key to suppress the multiples and bringout the deeper details as required by clients (Fig.-5). The results obtained with two softwares in suppressing the noises / multiples energy and bringing out deeper reflection were visibly different (Fig.6).

Initial velocity analysis after deconvolution was carried out in order to have the first estimate of the velocity which has been utilized in the application of Radon. Subsequently after application of residual and Radon Velocity analysis has been done with a grid of 400 X 500 mts. The stacks seen with this velocity appeared to have every information required by client. This velocity has been used for the target lines PSTM to get time migrated gathers to update the RMS velocity. It is observed that remnant multiples causes confusion in picking the RMS velocity at places. Hence, another pass of multiple attenuation is applied before picking RMS velocity. PSTM was carried out using the final velocity volume. Post stack processing (Random Noise attenuation and filtering) further improved the PSTM volume (Fig.7 a,b).

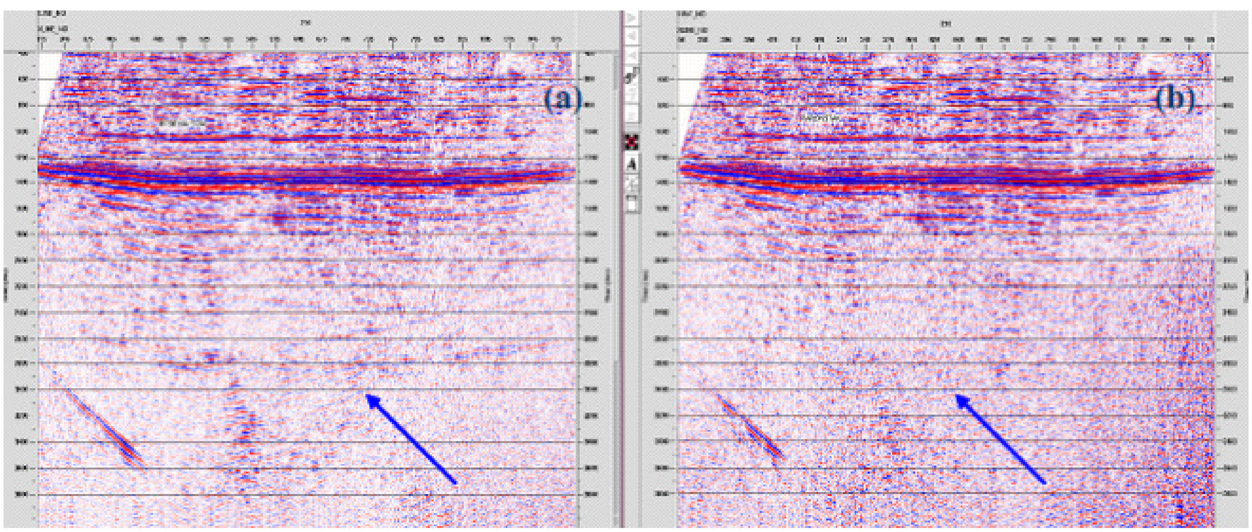

Fig.- 5 Kalol Multiple (marked by arrow) is attenuated with the application of Radon as observed in stack (b)

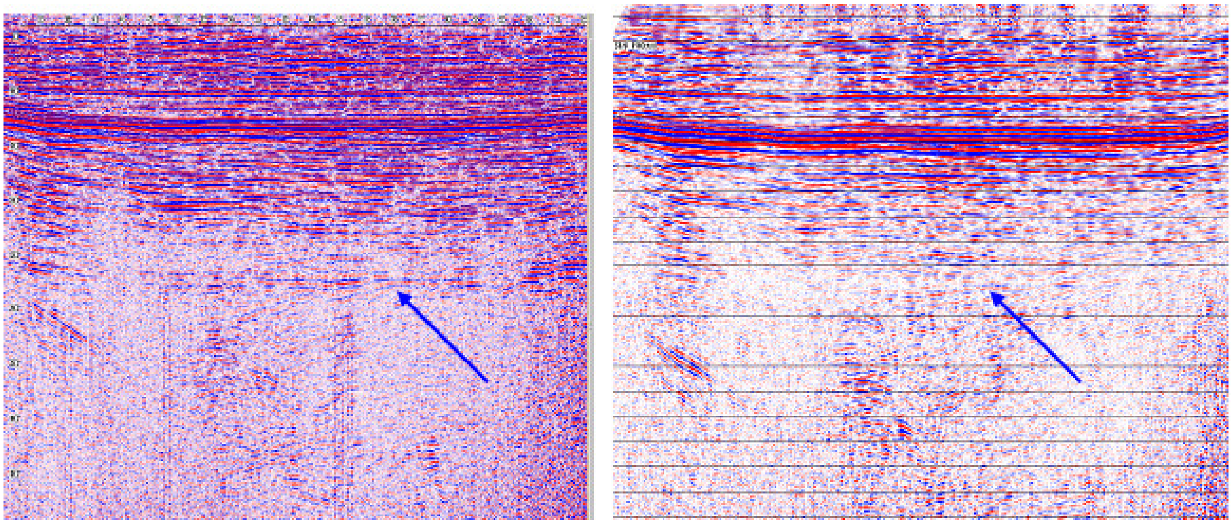

Fig -6 Comparison of stack sections after multiple attenuation with two different softwares. Multiple attenuation in section (b) is better (marked with arrow); hence this software is used for further processing.

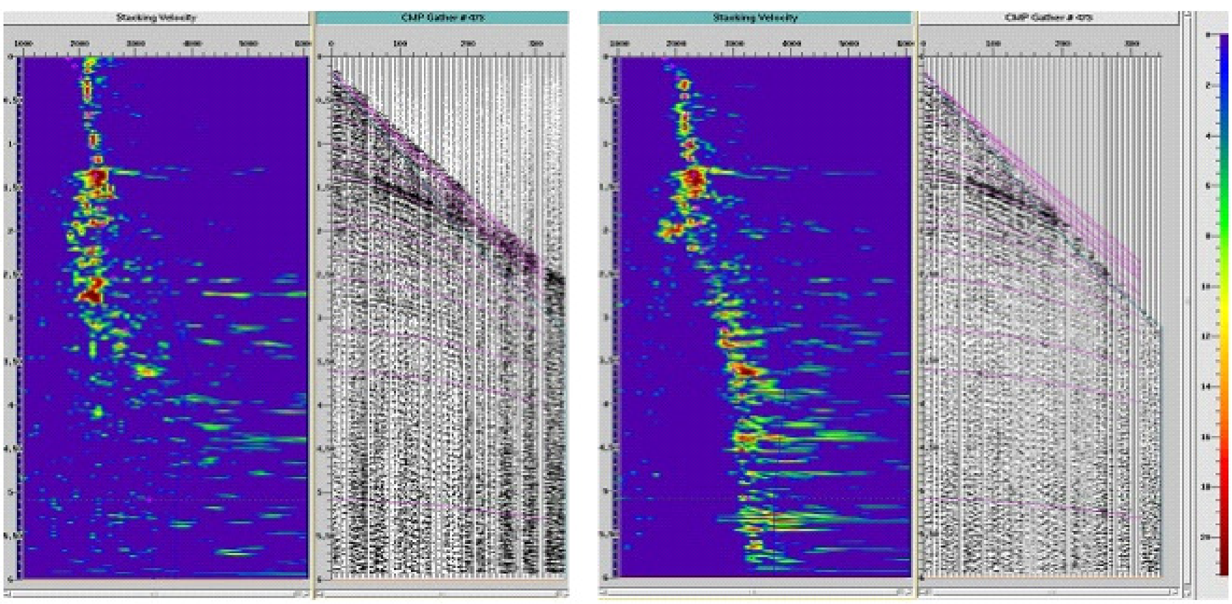

Fig.-7 Velocity analysis before (a) and after (b) multiple attenuation.

Results and Discussion

The data processed at three different times were conditioned with three different softwares before pre-stack time migration. In the first attempt Kalol multiple was successfully removed but has also decreased amplitude of deeper events (Fig.-8). In second attempt, Kalol multiple attenuation has been poor. This resulted in section with multiple and descrete deeper reflections making it difficult to map (Fig.-9). The attenuation of multiple with careful application of Radon filter has brought out the deeper events more prominently. Care is taken in applying the radon filter in keeping balance between suppression of multiple vs deeper events (Fig.-10). This has resulted in some remnant of multiple but stress is given so that deeper events are not affected.

Value addition/Conclusion

The objective of the present processing to attenuate the multiple of Kalol and bring out the features below Olpad, is successfully achieved. The present work paves a direction toward multiple free processing below Kalol in Cambay basin which had always remained a challenge to the processors. The clarity in sequence below Kalol viz YCS, OCS, OLPAD and DECCAN TRAP has given a new dimension to the processors and an ease to map these horizons for interpreters.

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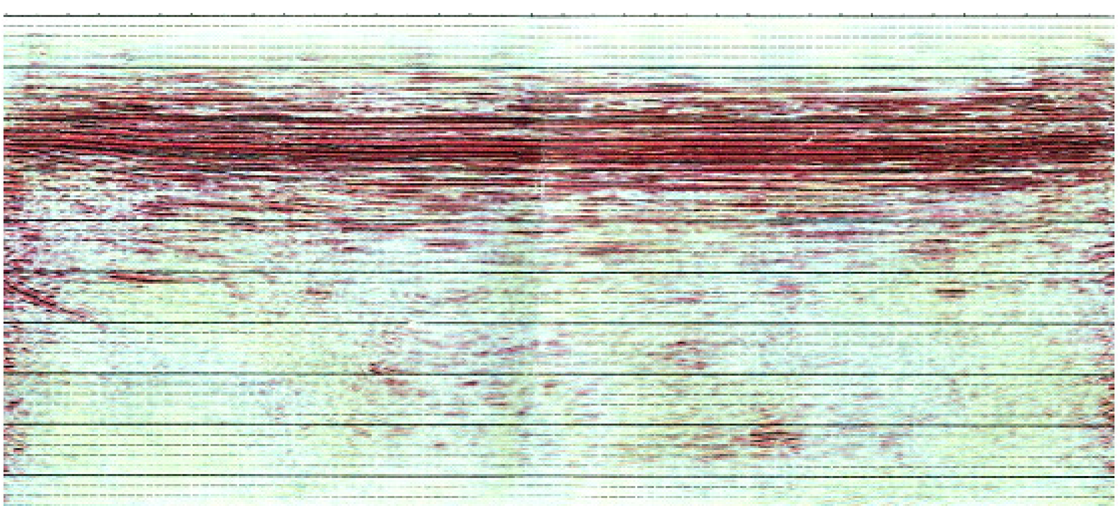

Fig. 8 In line (180) PSTM section processed in first attempt.

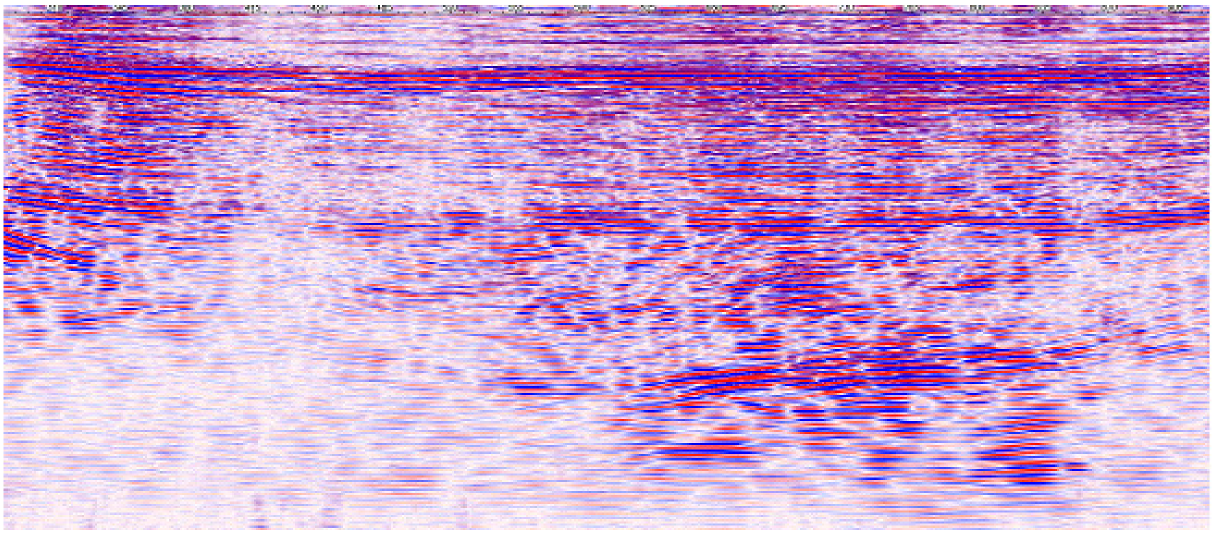

Fig. 9 In line (180) PSTM section processed earlier in second attempt

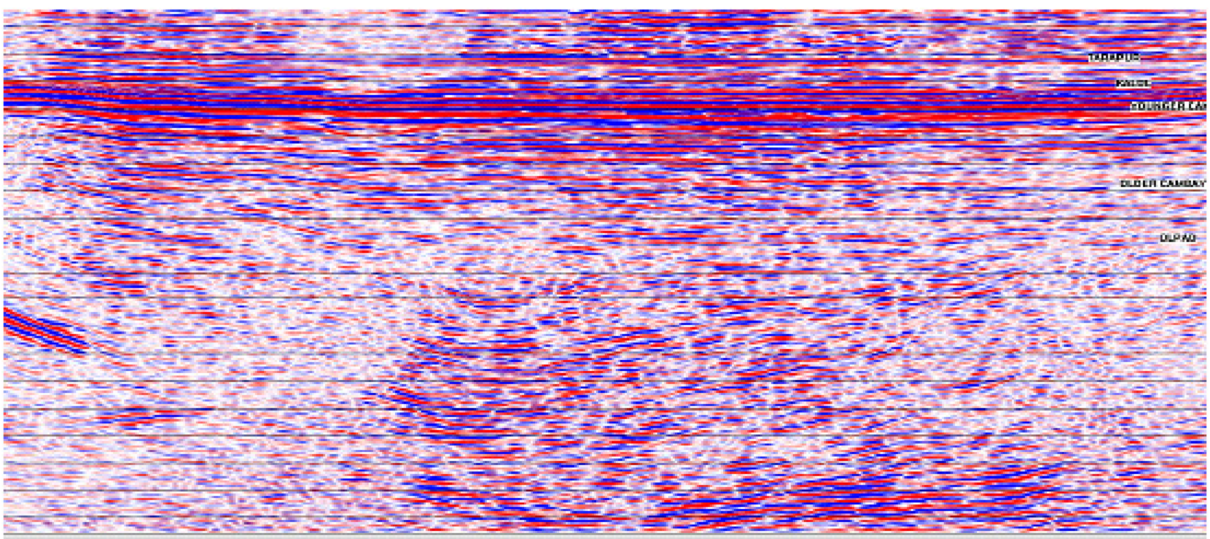

Fig. 10 Inline (180) PSTM section reprocessed at the centre.