A new approach for data regularization - A case study from Western Onshore Basin

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Abstract

Fast industrial growth and increased cultural activities has affected quality of land seismic data in recent times, especially at near offsets. Despite best efforts gaps in near offsets are unavoidable. This deficiency in acquired data degrades quality of processed output and hinders geological interpretation by the end users, especially in shallow zones.

To address this issue, a new 5D data interpolation method, in frequency space domain, is used on 3D seismic data of WON basin. The area of study, located in the Narmada block of south cambay basin in Gujarat, was taken up for evaluation of shallow gas prospectivety in view of encouraging results in shallow regions.

The results show better imaging and event continuity in the shallow zone as compared to the earlier processed output due to filling of near offset gaps, crucial for imaging at shallow levels, prior to migration.

Introduction

The area of study is a small field located in the Narmada tectonic block of south cambay basin in Gujarat (Fig-1). The Cambay basin is an intra cratonic basin which came into existence at the close of Mesozoic period by the development of tensional faults along its margins. The area of operation lies in Narmada tectonic block of Cambay Basin. The generalized stratigraphy of Cambay basin is shown in (fig-2).

In Narmada block, Ankleshwar Formation was deposited under the major deltaic and inter-tidal environment. Two major sand units namely Hazad and Ardol members were deposited during this period separated by thin shales of Kanwa and Telwa members. The subsequent major regression deposited the Dadhar formation under deltaic to pro-deltaic environment. The end of late Eocene to Oligocene is demarcated by an unconformity. This unconformity was overlain by Neogene sequence of Tadkeshwar, Babaguru, Kand and Jagadia formations which were deposited during Miocene age. During Pleistocene to Recent, the basin was covered by Gujarat Alluvium. The identified hydrocarbon bearing fields in Narmada-Broach Block are Ankleshwar, Kosamba, Sisodara, Olpad, Elao, Katpur and Kim.

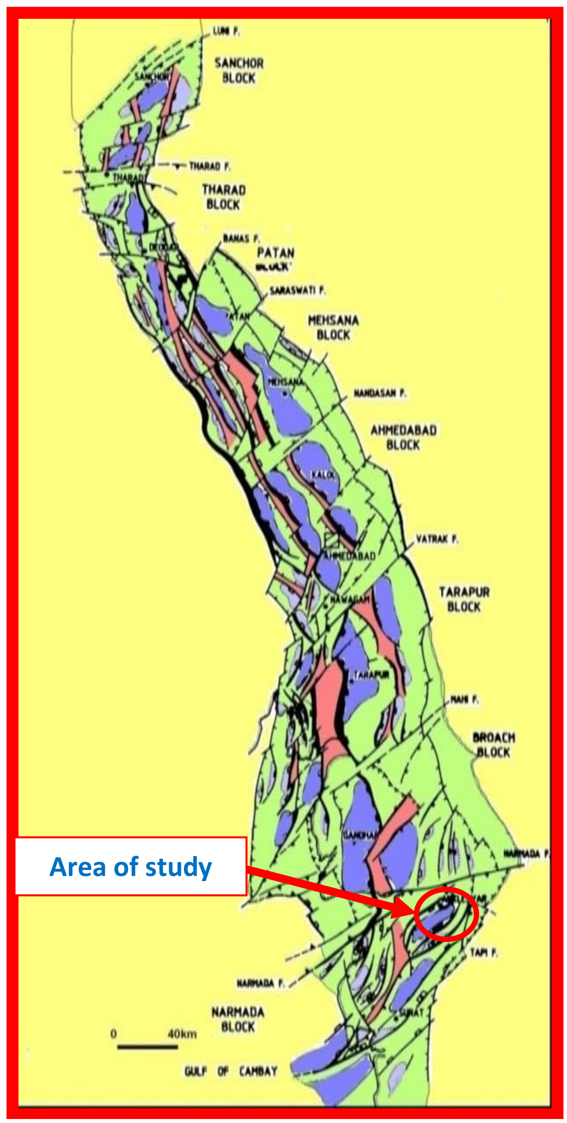

Fig-1. Location map of the area

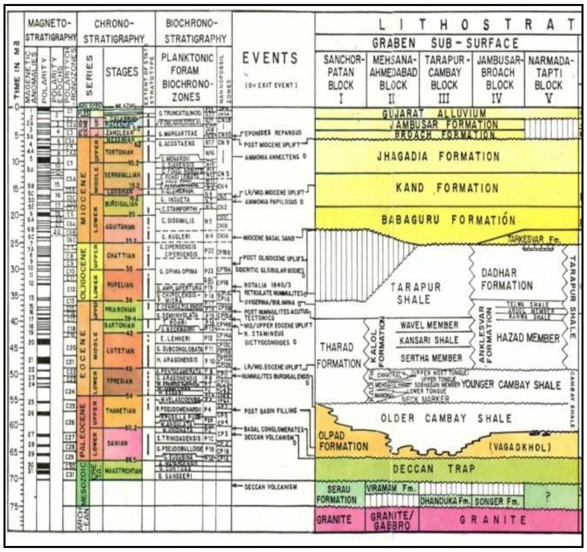

Fig-2. General stratigraphy of Western Offshore Basin.

Objective of study

The objective of the study is evaluation of shallow gas prospectivety in Neogene sequence of Tadk[i]eshwar, Babaguru, Kand and Jagadia formations (Miocene age) in view of encouraging results at shallower levels. The zone of interest is 0 ms to 1000 ms TWT. Seismic events at shallow levels, which were not clearly visible / interpretable in earlier processed volume, are to be enhanced by improving imaging and event continuity.

Methodology

In general, prior to pre stack time migration data, sorted in different offset classes, is regularized. The purpose is to remove redundant (duplicate) traces, retaining trace near to bin center, and to fill for the missing trace. The purpose of data regularization is ideally to have one trace per offset class in each bin.

In the earlier interpolation approach, gaps / missing traces in offset classes in the bin were filled by sorting data in xline direction and putting a live trace, using amplitudes of nearby traces, there. The exercise was repeated by resorting data in inline direction. This way gaps of small size, of the order of a few bins, could be filled.

In this method, the wavefield is reconstructed in the Fourier domain using an iterative approach, with the constraint of the irregularly sampled input wavefield. After the estimation of the wavefield in the Fourier domain, a standard inverse discrete Fourier transform can be used to reconstruct new seismic traces at any desired spatial location, for example on a regular grid. The new method, supports anti-aliasing or beyond aliasing interpolation by the application of priors at higher frequencies, which help putting the f-k energy to its correct location.

Irregular sampling causes energy of a certain spatial frequency to leak to nearby frequencies if a direct forward DFT is done. To improve on the results that could be obtained using a forward DFT, the transformation of the irregular sampled data to the Fourier domain is treated as an estimation/inversion problem. The algorithm works as - 1D FFT for each trace along the time direction (to frequency domain), 2D discrete Fourier transform to the f-x-y data to f-kx-ky along the two spatial dimensions for each frequency, then perform the following steps: Pick the Fourier coefficient (kx, ky) that has the largest amplitude. Add this component to the "estimated spectrum" and also: Transform this component back to the input locations. Subtract the component from the input data. Repeat the previous four steps for the specified number of iterations.

Anti-aliasing assumes that the energy spectrum distribution (power density spectrum) at higher aliased frequencies can be extrapolated from the energy distribution at lower unaliased frequencies. A prior as a function of wavenumber/slowness will be built up based on the idea that coherent energy will stack up while aliased energy or noise tend to cancel out. After the generation of the prior, it will be used as weights for the search of the dominant Fourier coefficient at higher frequencies. Assuming we have both the original and the aliased energy in the spectrum, the multiplication of this weight will amplify the correct energy and thus the correct one will be picked and removed.

After denoising, surface consistent amplitude balancing, decon, residual statics and offset splitting, regularization / interpolation of data is carried out using the above described interpolation methodology. This was followed by PSTM and post stack processing.

Results

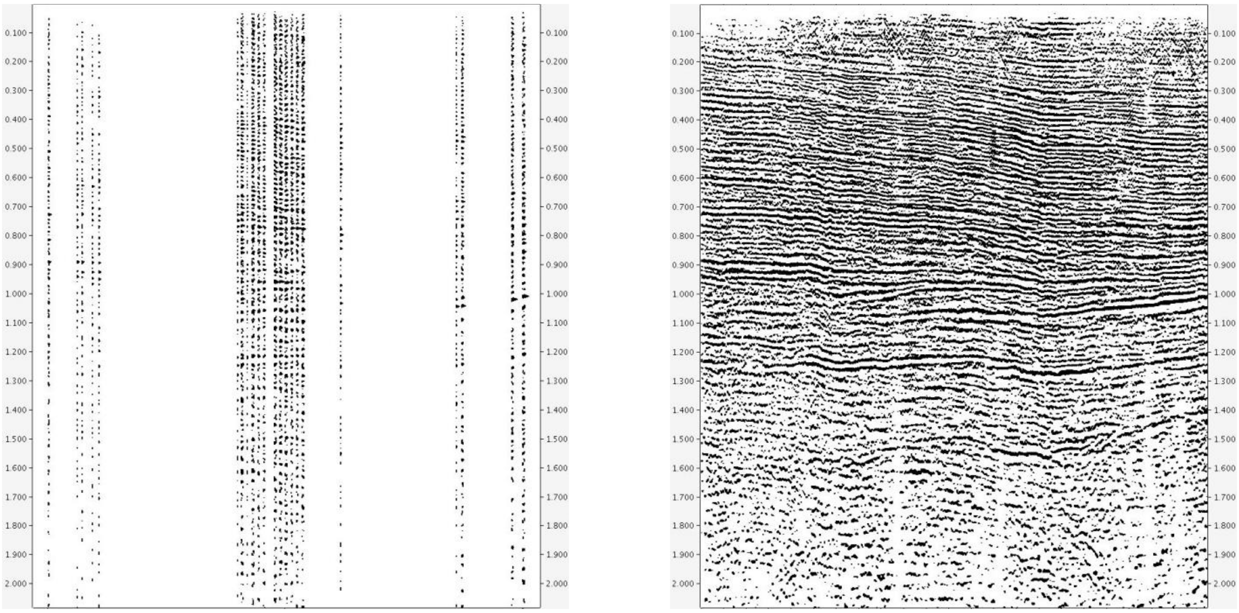

Fig-3. Offset 01 (0 – 72 m) along a xline before (left) and after (right) interpolation.

In Fig-3, Two sections along a xline before and after interpolation for offset class 01 (0 – 72 m) are shown. The data gaps are completely filled and continuity of events is drastically improved after 5D interpolation method using four dimensions namely inline, xline, offset and time.

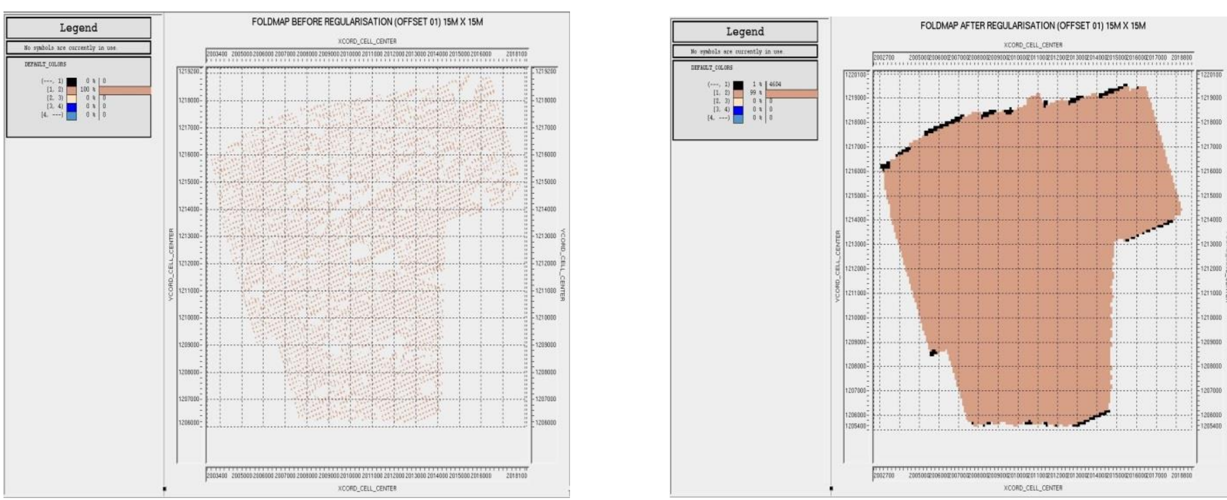

Fig-4. Foldmap for offset 01 (0 – 72 m) before (left) and after (right) interpolation.

In Fig-4, Foldmap of offset 01 before and after interpolation are shown. The data gaps are completely filled after interpolation with the new technique.

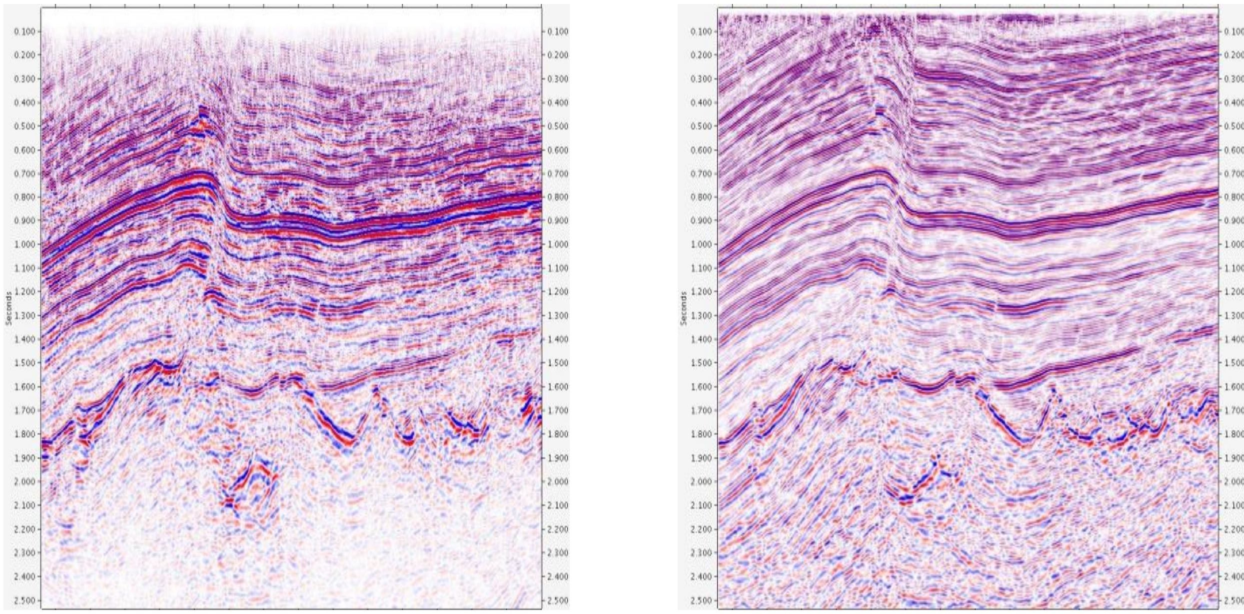

Fig-5. Migration stack of an inline (left) earlier processed (right) recently processed.

In Fig-5 Two migration stacks of the same line are shown. The improvement in imaging and event continuity, especially in the shallow zone, is clearly seen in the section where interpolation is done using the new technique.

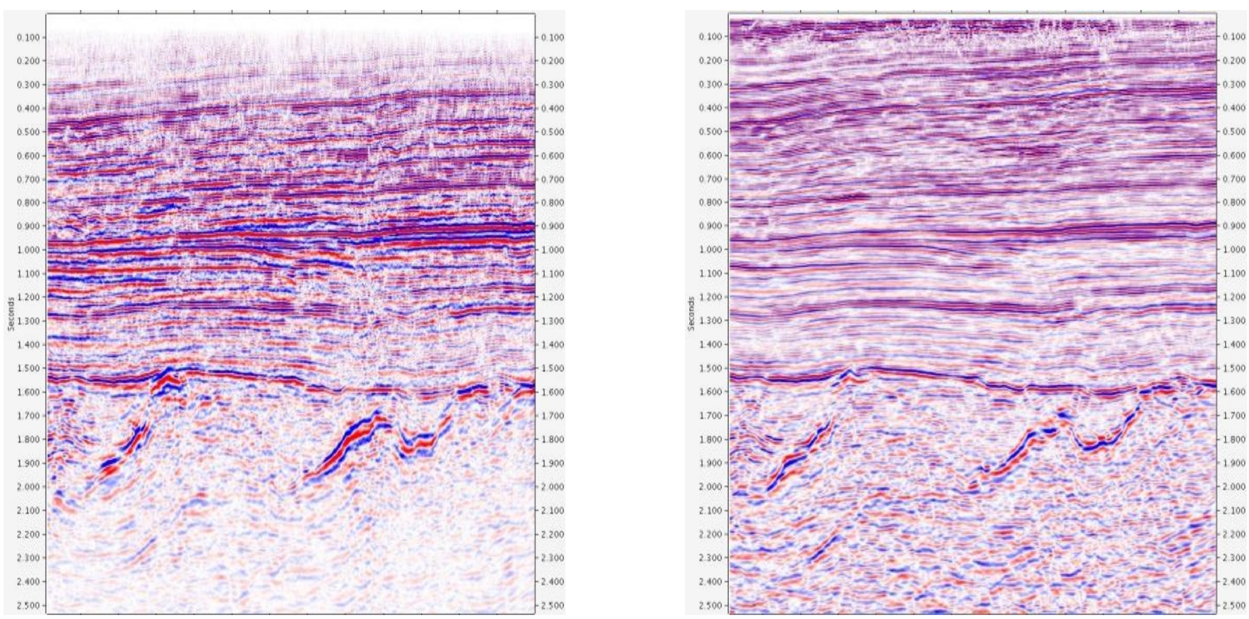

Fig-6. Migration stack of xline (left) earlier processed (right) recently processed.

The results are equally good in xline direction as seen in Fig-6.

For evaluation of the volume, time slices are taken at 100 ms, 200 ms and 500 ms (Fig-7, 8 and 9) from both data volumes and the quality of imaging and event continuity is improved significantly in the recently processed data using new interpolation technique.

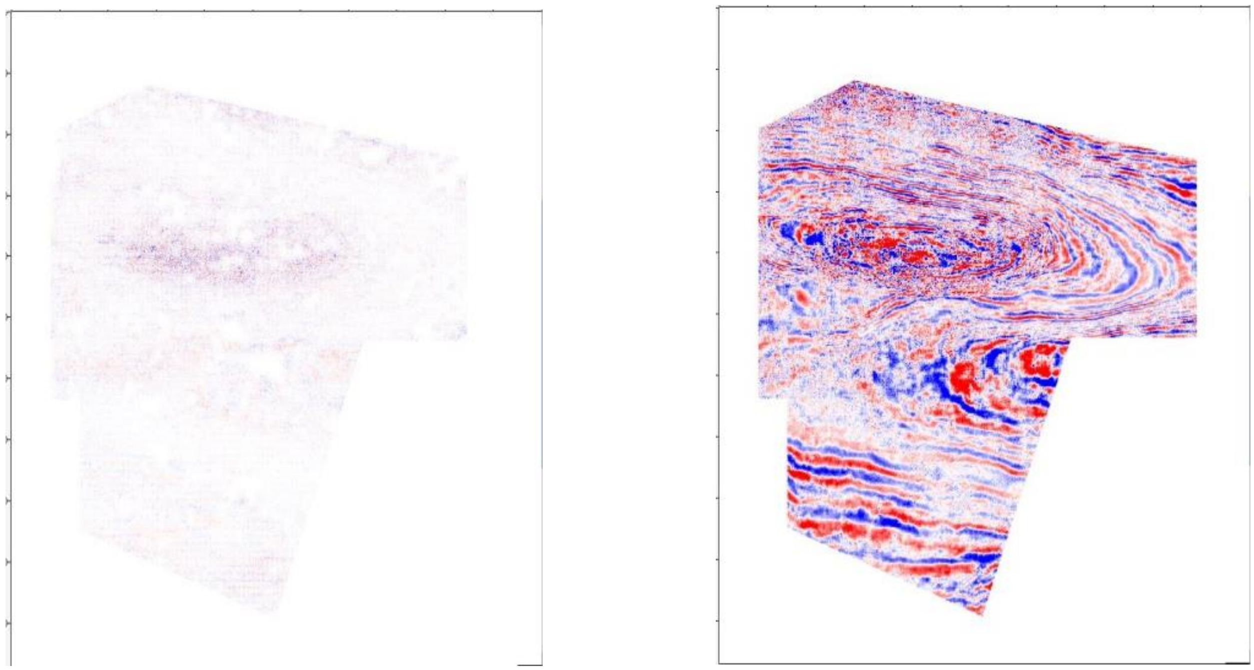

Fig-7. Time slice at 100 ms for (left) earlier processed and (right) recently processed.

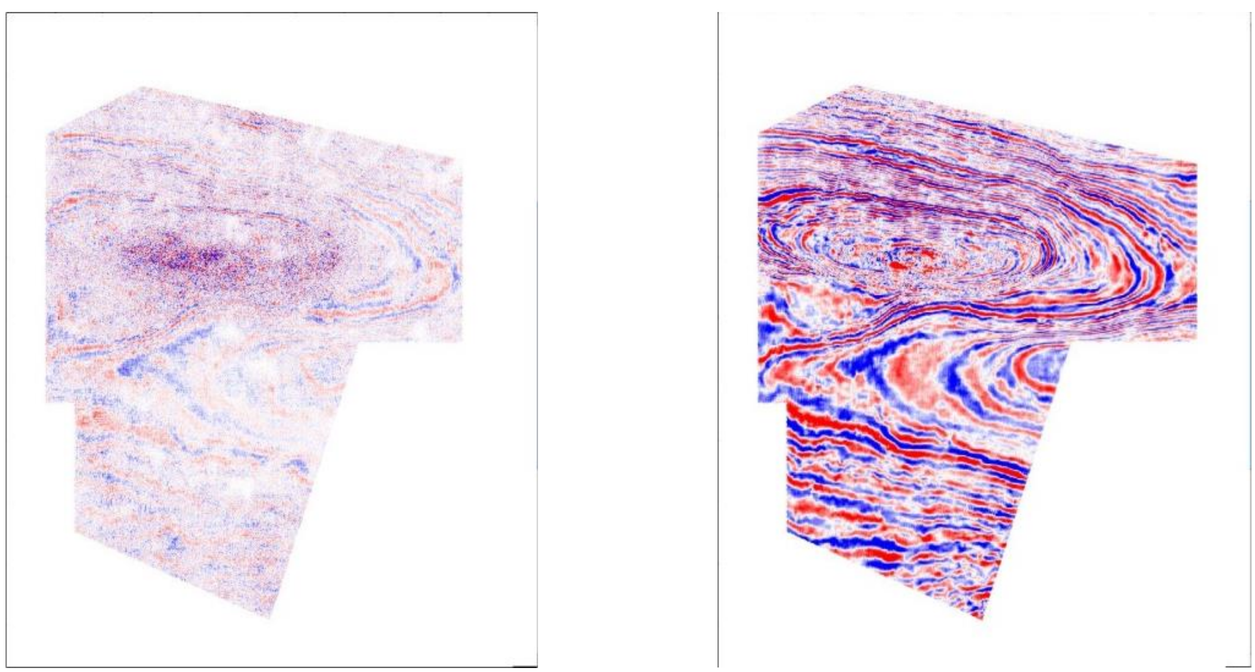

Fig-8. Time slice at 200 ms for (left) earlier processed and (right) recently processed.

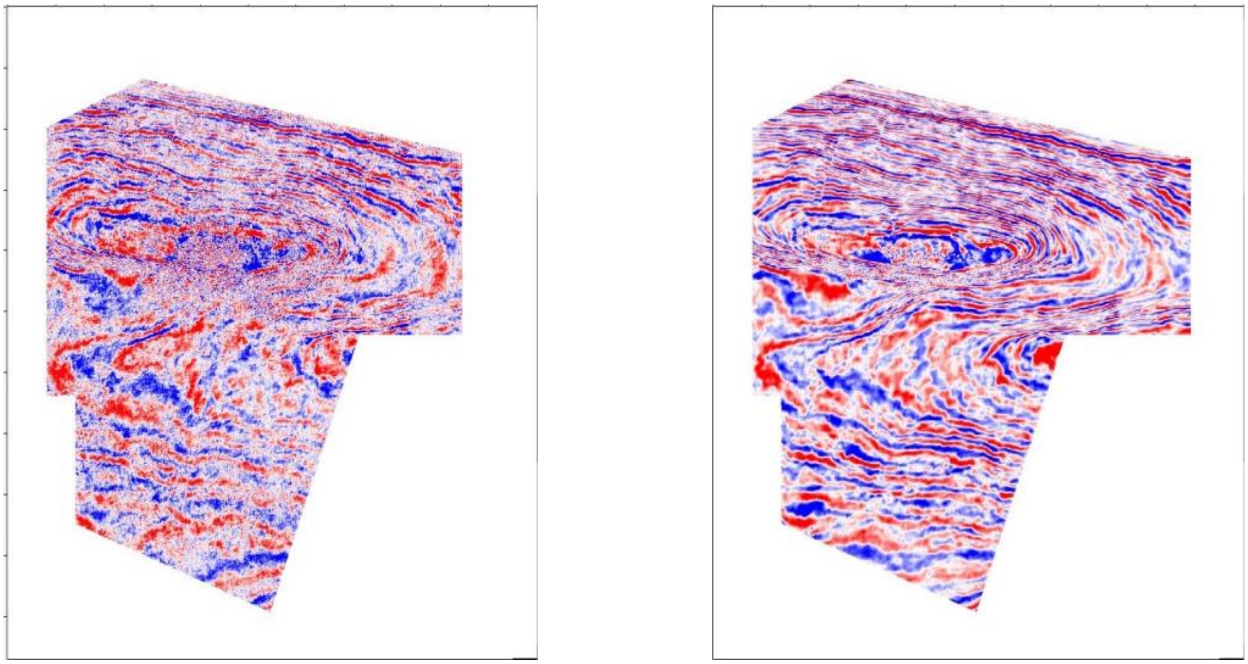

Fig-9. Time slice at 500 ms for (left) earlier processed and (right) recently processed.

Conclusions

The new approach for 5D data regularization, in f-x domain, has been demonstrated in the present study. It has been found that the seismic imaging and events' continuity has improved significantly as compared to the earlier processed output, making the new data volume highly amenable for shallow gas prospectivety analysis.

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The views expressed in this work are solely of the authors and do not necessarily reflect the views of ONGC.

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