Application of the Predictive deconvolution on a seismic line Al-Najaf and Al-Muthanna Governorates in Southern Iraq

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Abstract

This study deals with the processing of field seismic data for a seismic line located within the administrative boundaries of Najaf and Muthanna governorates in southern Iraq (7Gn 21) with a length of 54 km. The study was conducted within the Processing Department of the Oil Exploration Company using the Omega system, which contains a large number of programs that deal with processing, through the use of these programs applied predictive deconvolution of both(gap) and (spike). The final section was produced for both types. The gap predictive deconvolution gave improvement in the shallow reflectors while in deep reflectors it did not give a good improvement, thus giving a good continuity of the reflectors at the expense of resolution, whereas spike predictive deconvolution caused an increase in frequency noise in seismic sections, giving a good resolution at the expense of continuity.

Keywords: Seismic data, Predictive deconvolution, Reflectors, AL-Najaf, AL-Muthanna, Iraq

تطبيق التفلفل التنبئي على مقطع زلزالي في محافظتي النجف والمثنى جنوبي العراق

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الخلاصة

تتناول هذه الدراسة معالجة البيانات الزلزالية الحقلية للخط الزلزالي الواقع ضمن الحدود الادارية لمحافظتي النجف والمثنى في جنوب العراق وهو (7Gn 21) بطول 54 كم. اجريت الدراسة ضمن قسم المعالجة في شركة الاستكشافات النفطية باستخدام منظومة الاوميكا التي تحتوي على عدد كبير من البرامج التي تخص عمليات المعالجة، من خلال استخدام هذه البرامج قمنا بتطبيق التفلل التنبئي بنوعيه الفجوة والنبضة الحادة. تم انتاج المقطع النهائي لكلا النوعين، التفلل التنبئي المفتوح اعطى تحسن في العواكس الضحلة بينما في العواكس العميقة لم يعطي تحسن بشكل جيد، وبذلك اعطى استمرارية جيدة للعواكس على حساب الدقة، بينما التفلل التنبئي النبضي سبب زيادة في frequency noise في المقاطع الزلزالية، واعطى زيادة في الدقة على حساب الاستمرارية.

Introduction

he importance of the seismic methods lies above all in the fact that their data, if properly process, yield an almost unique and unambiguous interpretation. The incomparably most important application of seismic methods is in oil prospecting [1]. Seismic reflection gives a more direct and detailed picture of subsurface geological structures, and is appropriate in areas where oil is in structural traps, but it is also useful for determining the details of certain types of stratigraphic features [2].

Seismic processing aims to increase the signal / noise ratio that will assist in the interpretation of this information. Processes include the application of known perturbing causes, the rearrangement of

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information and filtering according to some controls, view data in other formats ... etc [3]. Thus, the results of seismic processing depend mainly on field controls used during field registration.[4] indicates to the degree of coverage and quality of rocks on the surface and even adverse weather conditions can affect the quality of field recordings. Thus, the processing of data uses a lot of mathematical means in their work and can be divided into the sequence of these work to pre-stack and post-stack and important deconvolution, stack and migration. The aim of this research is to apply predictive deconvolution on selected seismic data.

Location of Study area

The survey area block11 is located in the southern part of Iraq within the administrative boundaries of Al- Muthanna and Al- Najaf governorates in Western Desert. The studied area is about (4822) km^2 as shown in Figure- 1[5]. The block11 area is structurally located within the Salman zone of the stable shelf according to the structural map of Iraq prepared by the Established State of Geological Survey and Minerals in 1984 [6].
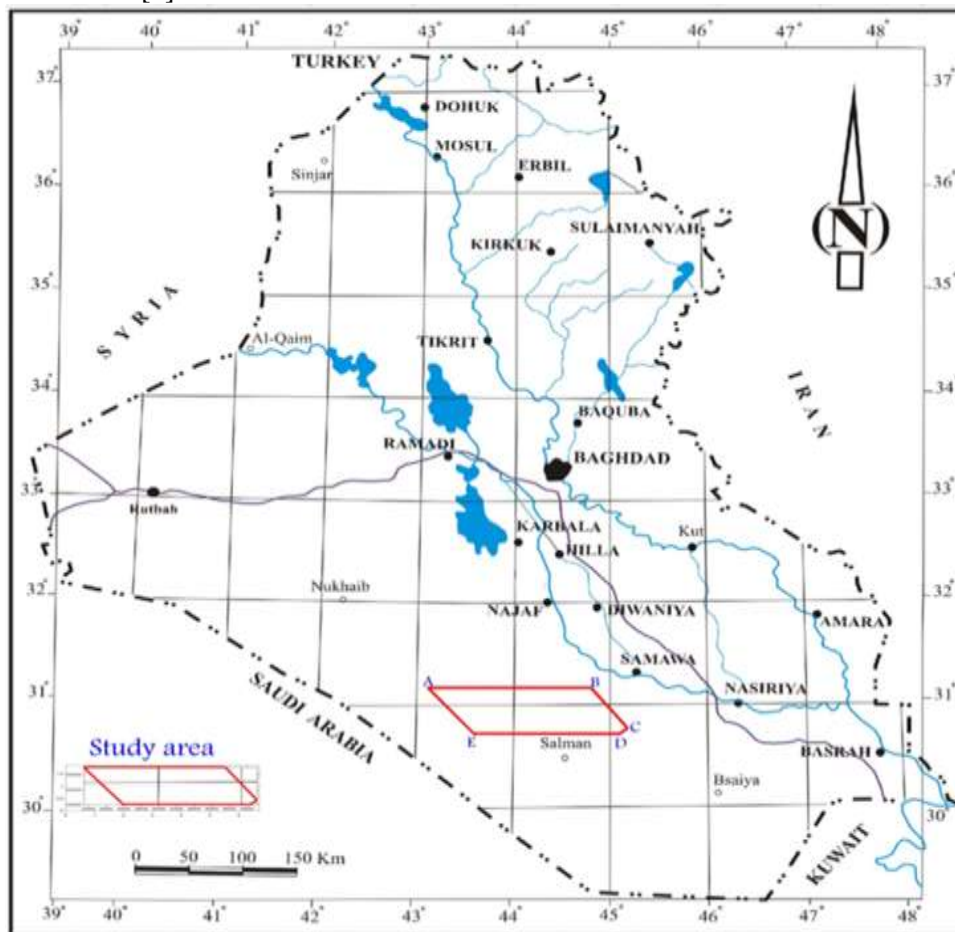
Figure 1- Location map of study area

Theoretical background

The purpose of seismic data processing alteration of seismic data to suppress noise, enhance signal and migrate seismic events to the appropriate location in space. Processing steps typically include analysis of velocities and frequencies, static corrections, deconvolution, normal move out, dip move out, stacking, and migration, which can be performed before or after stacking. Seismic processing facilitates better interpretation because subsurface structures and reflection geometries are more apparent [7]. Deconvolution is a filtering process that removes a wavelet from the recorded seismic trace [8]. This is done by reversing the process of convolution [9]. The attenuation of short-period multiples (most notably reverberations from, shallow surface-bottom) can be achieved with predictive deconvolution [10]. The periodicity of the multiples is exploited to design an operator, which identifies and removes the predictable part of the wavelet, leaving only its non-predictable part (signal) [11]

A- The predictive deconvolution theory

Predictive deconvolution uses the autocorrelation of a trace to ascertain the periodicities within the data .The geophysicist determines from the autocorrelation , the necessary operator length , usually a few hundred milliseconds , that will span the significant reverberation – caused energy on the autocorrelation , and a gap , or delay time after the zero lag value. The autocorrelation values after the gap for the length of the operator constitute the timing information of the reverberations that will be predicted. The filter designed from the autocorrelation , when convolved with the data trace , predicts reverberations and multiples The predicted trace is subtracted from the observed trace to give the prediction error , which should be the trace with the predicted reverberations and multiples removed. Primaries are considered unpredictable , so they remain , while the predictable reverberations and multiples are removed. The prediction – error trace is output as the result of the process use of the earlier part of a seismic trace to predict and ultimately deconvolve the latter part of the trace gave rise to the name of the latter part of the trace gave rise to the name of the process, for a mathematical development of predictive deconvolution [12].

B- Parameters that control deconvolution

Four parameters which are very important in the deconvolution methods these are:

1- The length of filter

As the length of the inverse filter increases, the deconvolution result improves. However, if the inverse filter is too long, so this will be very important information that the geophysicist is trying to extract may be distorted. Also, because one of the purposes of deconvolution is to remove short-period multiples from the recorded seismic data, it is therefore important that the filter length, specified in milliseconds ,is long enough to include at least two bounces of the maximum reverberation time of the multiple reflections the geophysicist is trying to remove. This is because a strong multiple generators will generate multiples for both the down-going wave and the up-going wave. The multiple of the down-going wave is removed by a filter, which has the same length as the multiple periods [13].

2- The gap operator

Operator gap of the applied predictive deconvolution should be slightly larger than the reverberation period to be able to efficiently remove reverberations. In spiking deconvolution, usually a small operator gap (8–16) ms is used. With this small-gap operator, fairly spiked reflection-events with less spiky noise will be obtained [14].
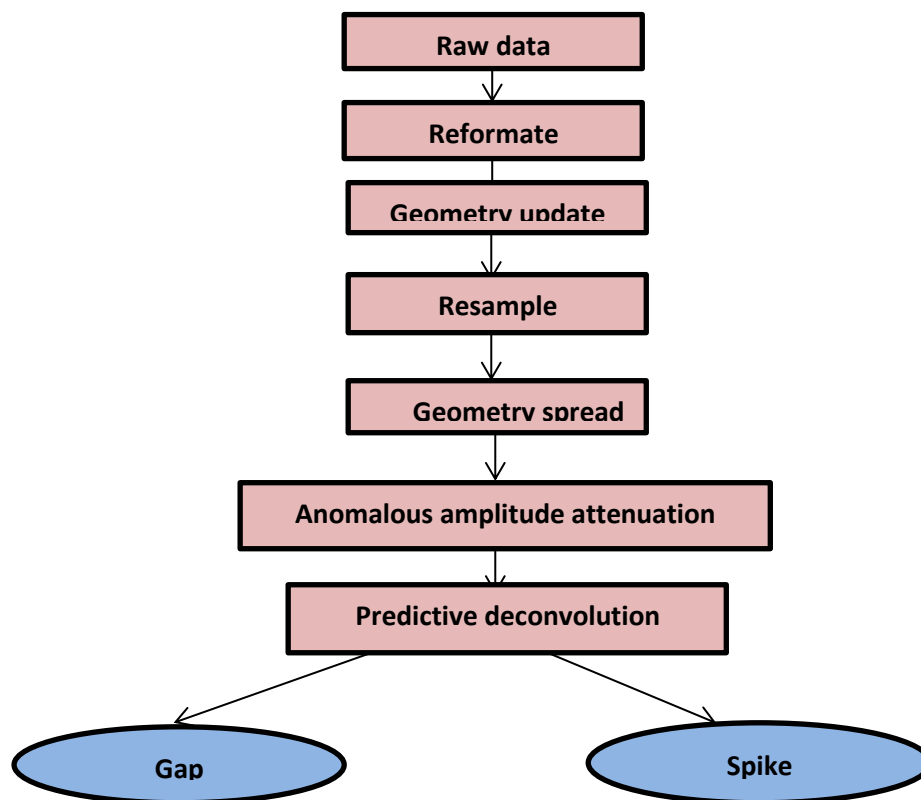
3-The gate design

A "window" needs to be specified, that is, the length of the seismic trace that would be auto-correlated .This is called the design gate. It is important that the gate is long in other to obtain a good sampling of the subsurface geology. The design gate is usually limited to the part of the seismic data that contains the best signal [13].

4- Pre-whitening noise

It is help in computation stability. For this purpose a small amount of white noise, typically 1–2 %, of the zero-lag of the autocorrelation is added. In effect it is giving the amplitude spectrum a deconvolution level in order to avoid dividing by near-zero value in deconvolution-computations [14].

Data and Result:

According to the Iraqi Oil Exploration Company's plan, two-dimensional survey was conducted for block 11 of Al Muthanna and Najaf governorates which represents 4822 km^2 study area. The project program was implemented by the Iraqi seismic crew of the Oil Exploration Company with a coverage of 2400% using vibrator as an energy source and normal geophones. The propagation type was a symmetrical spread, while the datum plane was 250 m below sea level. It was noticed that the quality of data is generally bad due to that the study area represents a desert area with high variation in the topography of the surface including valleys and highlands, which may cause problems in the reflections between recorders in the one hand and the recording device and vibrators in some areas.

So, a geospread compensation was applied on the field shots to make them clear and to treat disappearance that found in the energy to be able to see the effect of deconvolution. For this purpose, the line (7Gn 21) in the study area was processed. The seismic data processing of the line is obtained at the processing center of the Oil Exploration Company, according to the traditional processing sequence using the Omega system. Figure-2 represents flow chart of the processing sequence of deconvolution in current study.

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                    ┌──────────────────────┐
                    │       Raw data       │
                    └──────────┬───────────┘
                               ↓
                    ┌──────────────────────┐
                    │      Reformate       │
                    └──────────┬───────────┘
                               ↓
                    ┌──────────────────────┐
                    │    Geometry update   │
                    └──────────┬───────────┘
                               ↓
                    ┌──────────────────────┐
                    │       Resample       │
                    └──────────┬───────────┘
                               ↓
                    ┌──────────────────────┐
                    │    Geometry spread   │
                    └──────────┬───────────┘
                               ↓
              ┌───────────────────────────────────┐
              │   Anomalous amplitude attenuation  │
              └─────────────────┬─────────────────┘
                                ↓
              ┌───────────────────────────────────┐
              │       Predictive deconvolution    │
              └──────────┬──────────────┬─────────┘
                   ↙                          ↘
          ╭──────────────╮            ╭──────────────╮
          │     Gap      │            │     Spike    │
          ╰──────────────╯            ╰──────────────╯
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Figure 2- Flow chart of the processing sequence of predictive deconvolution

Predictive deconvolution (trace by trace):

The primary objective of all seismic processing is to convert the recorded information into a form that facilitates geological exploration. One goal of the processing is to remove or at least suppress all noise in the form of rebound and complications.

Predictive deconvolution is an integral part of seismic data processing aimed to compressing seismic wavelets, thus attenuating or attenuating complications involving surface or semi-surface reflectors. This type of deconvolution is effective in syntactic and layered interpretations where the appropriate type is chosen by the client.

Certain assumptions are placed in the predictive deconvolution during the data processing:

1. The earth consists of horizontal layers of constant velocity.

2. The source of the waveform does not change through in the ground, which means that it is stationary.

3. Noise element n (t) is zero.

4 - Reflectivity is a random process in the sense that the seismic plan has the characteristics of seismic waves.

5- Seismic waves are the minimum phase.

Although the application of trace by trace does not greatly improve accuracy but results in suppression of complications and improved signal-to-noise ratio to a large extent in both pre-stack and post-stack data, these results are positively proportional to those obtained using surface consistent deconvolution because it requires self-measurement of data to obtain acceptable results.

There are two types of predictive deconvolution that have been applied in the current study gapped predictive deconvolution and spiking predictive deconvolution.
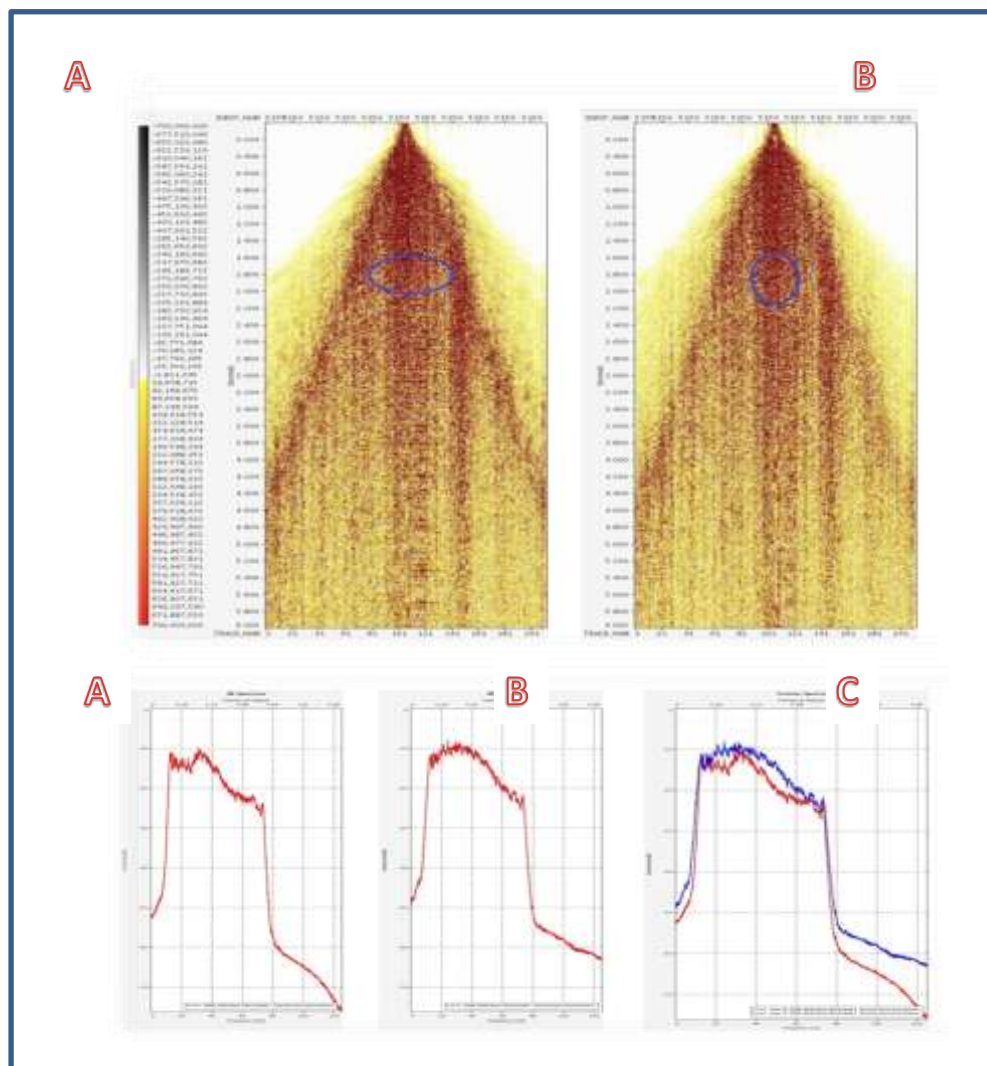
Gapped predictive deconvolution:

This type is applied to the selected line data (7Gn 21) using the operator gap, operator length, and white noise. Where the operator gap has more influence on the final appearance of the data. Choosing of the operator gap will affect the amplitude iof the resulting data. The shorter gap will cause more wavelet pressure or spectral bleaching and will enhance noise for high and low frequencies. While the operator length has a greater effect on the degree of repression of complications performed by the

predictive deconvolution. The chosen value of the operator length will lead to a spectral bleaching process and will be effective in suppressing the multipliers, since the longer operator length sometimes strengthens the geology but will not be longer than (300ms) because it will work poorly to suppress the multiples. White noise is added to the zero-lag of the auto-correlation to stabilize the spin and effectively stop noise in the data, it is advisable to select a small value as much as possible to increase resolution.

Several parameters have been tested on the lines (7Gn 21) as follows:

Operator length (120, 140, 164, 220), operator gap (16, 18, 22, 28). The best parameters are operator length 164, operator gap 28 and white noise added 0.01% and applied on line because they gave the best result compared to others parameters.

Figure- 3 represents the shot and amplitude spectrum of the line (7Gn 21) before and after deconvolution. In the shot after applying deconvolution, it shows an improvement in the shallow reflectors to approximately(2000ms). The amplitude spectrum Figure- (3A) represents the data where the frequency range of the real layers of the region is roughly (8-50 Hz). The amount of capacitive amplitude added to the range is a reference to range data where the

process predictive gapped deconvolution. This range is improved the amplitude and

frequency and is intended to output the amplitude spectrum. All frequencies have bandwidth because it increases low frequency and high frequency thus, the spectrum contained almost all frequencies as it became a box and in turn increased resolution.

Figure 3- shows shots and amplitude spectrum for line (7Gn 21): (A) shot and spectral analysis before applying predictive gapped deconvolution, (B) shot and spectral analysis after applying predictive

gapped deconvolution, (C) overlay spectral analysis, the red line before deconvolution and the blue line after applying deconvolution.

Figures –(4, 5) the autocorrelation of the line (7Gn 21) before and after deconvolution, in line (7Gn 21) the deconvolution gap applied to the reinforcement of the bandwidth with the zero-lag which improved the center of the wave and eliminated side-lobes with some noise.
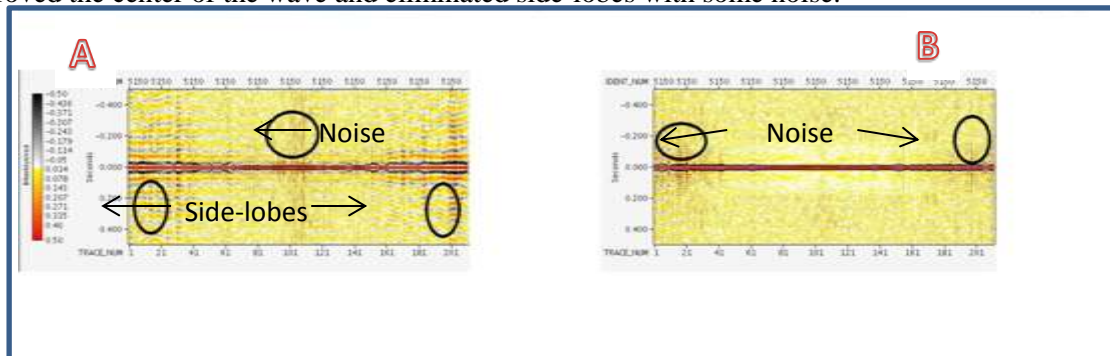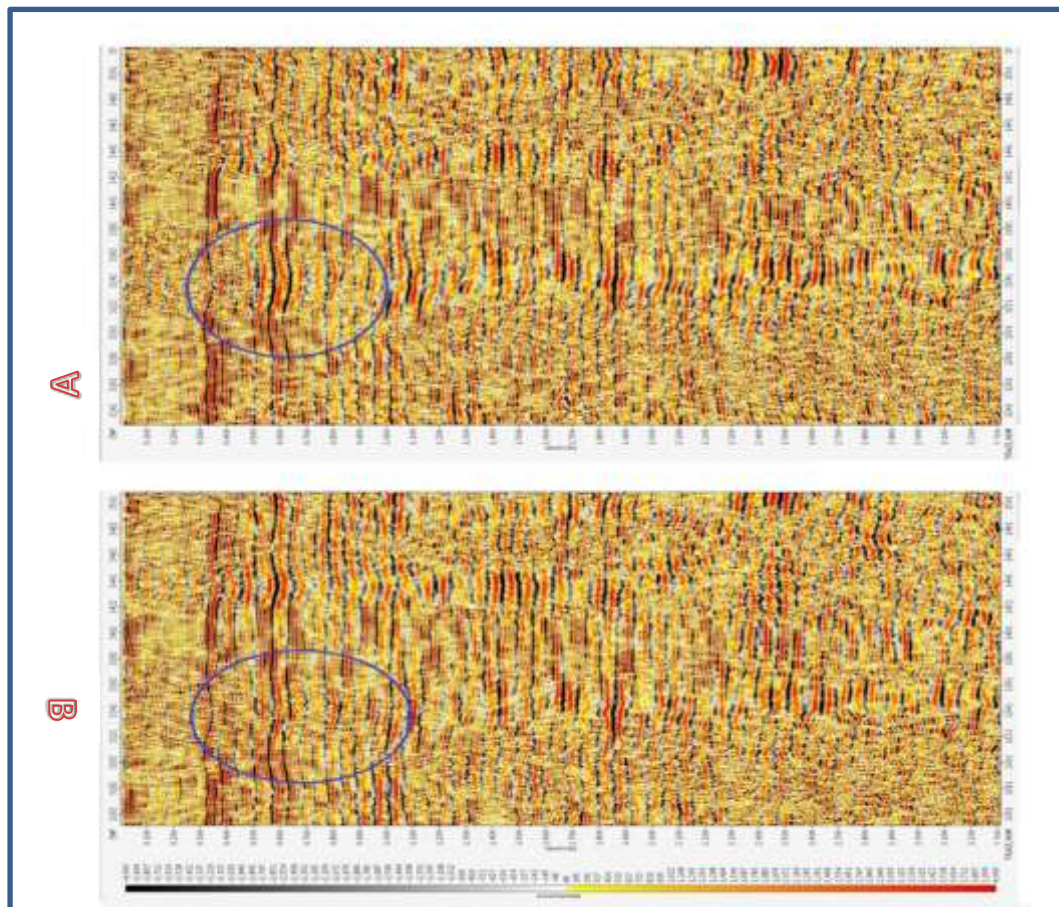

Figure 4- the autocorrelation for line (7Gn 21): (A) Before applying predictive gapped deconvolution, (B) After applying predictive gapped deconvolution.

The final stack was then extracted for the line, where RMS amplitude gain was applied at 250ms, random noise attenuation was used, and then the TV- Filter dish was applied. The following filters were applied:

10/14 40/50 Hz 0- 1600 Time (ms)

10/14 35/45 Hz 2200- 6000 Time (ms)

Note that the signal-to-noise ratio has not improved significantly because the noise is higher than the data, but it has given good continuity to the reflectors at the expense of resolution. This type of deconvolution kept the waveform and thus maintained the thickness of the reflectors as in the

Figure 5- Final stacked section for line (7Gn 21): (A) Before applying predicti deconvolution, (B) After applying predictive gapped deconvolution
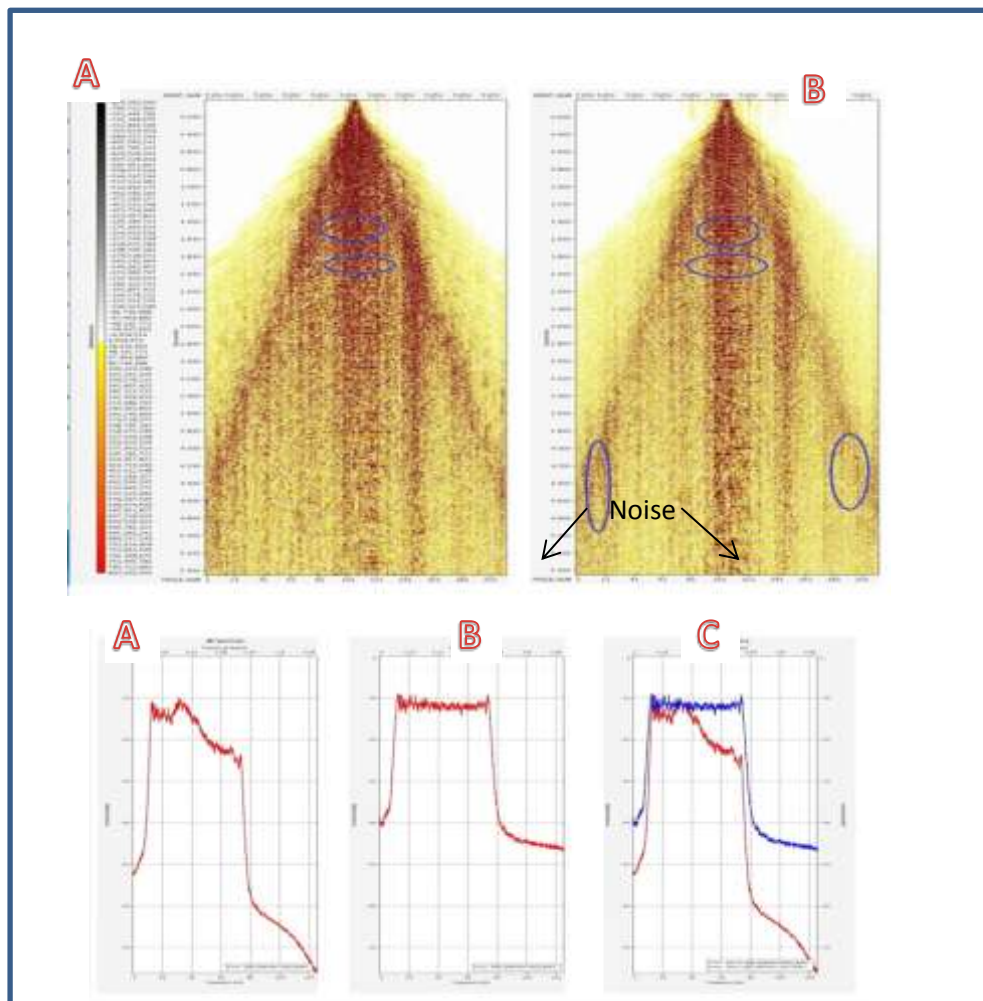
Spiking predictive deconvolution

This type has also been applied to the selected line data (7Gn 21) using operator length, operator gap, white noise. It is a special case in which the gap is adjusted on one sample which takes a sample rate and the resulting phase spectrum is zero. This type was applied to seismic data to compress the wavelet source embedded in seismic effects to improve temporal resolution.

In this type, since operator gap is set to the sample rate, operator length tests were performed only to select the best value. The values (140, 220, 164, 120) were selected. The value length 164 was chosen for the operator length because it gives the best result. The following parameters have been applied : The operator length 164, operator gap 4, white noise 0.01%. There are no established mathematical rules that limit the gap and operator length parameters, and are usually tested extensively and the therapist and interpreter use their experience and judgment to select the most desirable section.

Figure- 6 represents the shots and amplitude spectrum of the line (7Gn 21) before and after the application of spiking predictive deconvolution. Line (7Gn 21) gives clearly improvement in the shot to the extent (2000 ms) after (2000 ms) eaten of the bandwidth although above (2000 ms) also ate from the bandwidth but gives an improvement in the inductors. Also the noise was strong from (4000-5800 ms) because it increases the high frequency. At (2900 ms) note that it ate the reflectors and thus increased the bandwidth of the noise, also in (2000 - 3000 ms), increasing the frequency noise.

The amplitude spectrum of the line (7Gn 21) amplified the amplitude of the frequency range from 50-80 Hz almost constant, making the capacitance value constant and indicating the noise as indicated in the shot.

Figure 6- the shots and amplitude spectrum for line (7Gn 21): (A) shot and spectral analysis before applying spiking predictive deconvolution, (B) shot and spectral analysis after applying spiking predictive deconvolution, (C) overlay spectral analysis, the red line before deconvolution and the blue line after applying deconvolution

Figures- 7 represents the autocorrelation before and after the deconvolution of the line (7Gn 21). After applying this type of deconvolution, it works to strengthen the bandwidth with zero-lag but gives side-lobes in the middle with noise on the sides.
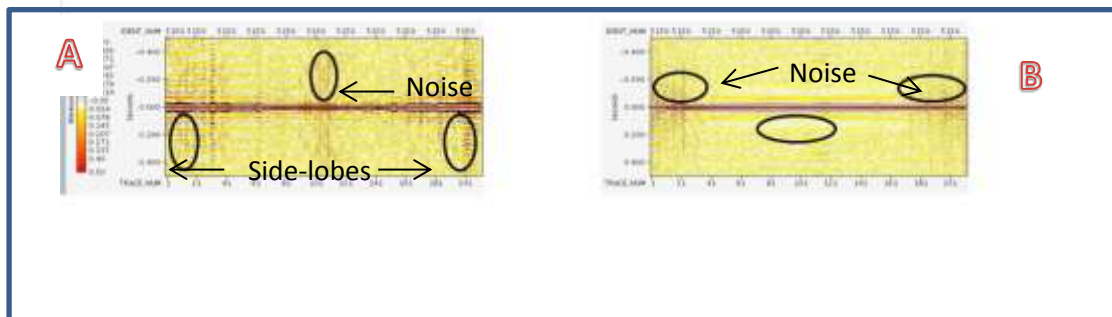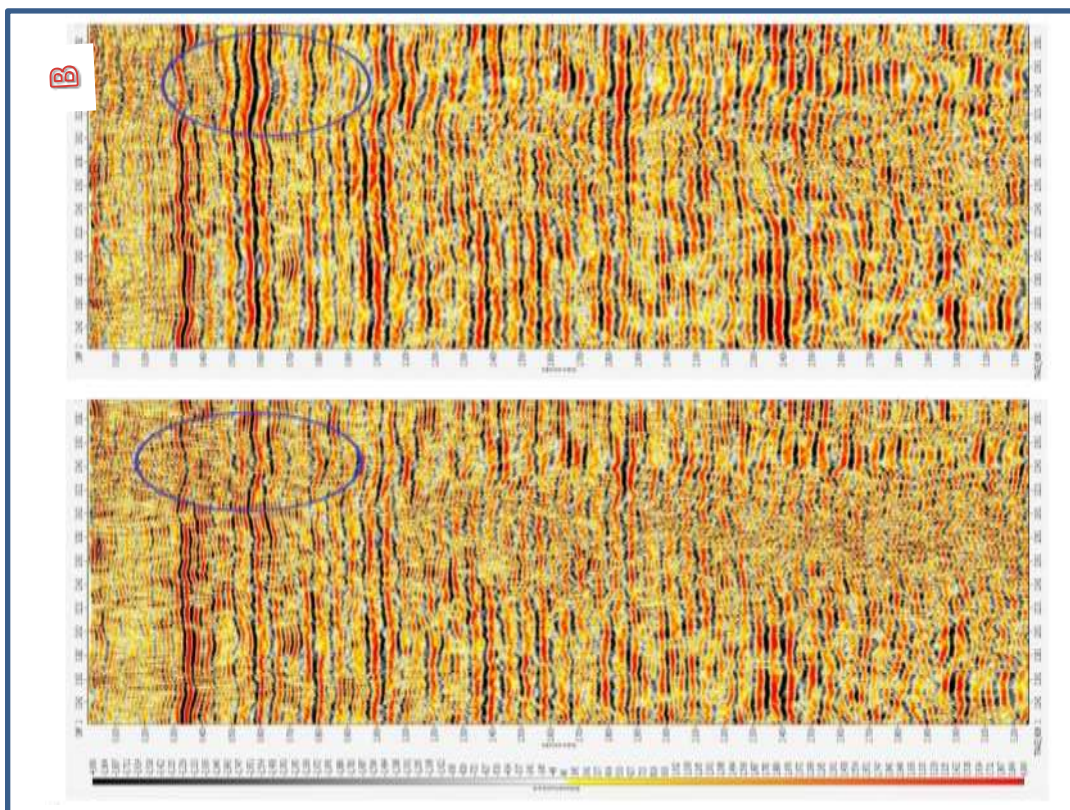

Figure 7- illustrates the autocorrelation for line (7Gn 21): (A) Before applying spiking predictive deconvolution, (B) After applying spiking predictive deconvolution

The final stack was then extracted for the line (7Gn 21), where RMS amplitude gain was applied at 250ms, random noise attenuation was used, and then the TV- Filter dish was applied. The following filters were applied:

10/14 40/50 Hz 0- 1600 Time (ms)

10/14 35/45 Hz 2200- 6000 Time (ms)

It was noted that this type gave an increase in accuracy at the expense of continuity and better estimate of reflectivity compared to the gap deconvolution, which worked to reduce the thickness of the reflectors and show other reflectors under it because it is not waveform because of the loss of high frequencies as in the Figure- 8.

Figure 8- Final stacked section for line (7Gn 21): (A) Before applying spiking predictive deconvolution, (B) After applying spiking predictive deconvolution

Conclusion

Based on the results obtained in this study, the authors have concluded as follows:

1 – The gap predictive deconvolution gives an improvement in the shallow reflectors for the shot while the deep reflectors did not improve well, with the amplitude spectrum contained the spectrum almost all frequencies and thus increased resolution. It gives good autocorrelation to the two lines where it spent on the existing side-lobes and thus gives good continuity of the reflectors at the expense of resolution.

2 – The spike predictive deconvolution actions to increase the bandwidth of the noise in the shot and it did not give a good autocorrelation compared to the gapped predictive deconvolution and thus this type gives an increase in resolution at the expense of continuity.

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