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Original Article

Effect of Noise on Seismic Data and Ways of its Attenuation and Suppression in Data Processing, Gumry Field, Melut Basin

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Abstract - *This work describes Seismic Data Processing and Noise Attenuation in the Gumry area, located in the Melut Basin in the South of Sudan. The data used in this study consist of six 2D lines (about 133 km in total), which were acquired by Blue Nile Geophysical Company (BGC) in 2004. The authors process the 2D data at the Data Processing Centre of the Blue Nile Processing Company (PBC) in Khartoum – Sudan. Land seismic data contains strong and source-generated noise, which deferent techniques eliminate. We use a band pass filter to attenuate this noise without affecting the data. This filter adaptively exploits both characteristics of the lower frequency and the lower velocity and high amplitude of the coherent noise (ground Role and linear noise). The result shows that band pass filtering and other techniques effectively attenuate the noise from our seismic data. This result enhanced the final migration sections obtained by post-migration methods.*

Keywords - *Seismic data processing, Noise attenuation, Bandpass filtering, Groun role, Melut basin.*

1. Introduction

The Melut Basin is a Meso-Cenozoic rift basin accompanied by the formation and development of the Central African Shear Zone (CASZ) on the Pre-Cambrian crystalline and metamorphic basement of lower relief [15]. Three stages of rift development and fracturing have been identified, stronger in the Early Cretaceous and Paleogene and weaker in the Late Cretaceous. Source rocks are the Lower Cretaceous lacustrine shales, whereas reservoirs and seals are Paleogene and Upper Cretaceous. Dominant structural styles are large-scale anticlines in the Paleogene sequences and antithetic normal fault-blocks in the Upper Cretaceous and Paleogene [19]. [7].The Melut Basin is characterized by flat plains composed of older alluvial, sand plains, lacustrine deposits and alluvial fans. This plain area is surrounded by regionally metamorphosed Precambrian and Paleozoic rocks and minor syn-late to post- tectonic. Mesozoic/Cenozoic intrusive igneous rocks [14]. Two types of sedimentary rocks of assumed Cretaceous age have been shown as undifferentiated sandstones, conglomerates and some mudstones. Ferruginous sandstones of secondary origin of no stratigraphic significance include some laterites. have described the sediments which are unfossiliferous [18,24].

1.1. Seismic reflection methods

They were derived from seismology: the science of earthquakes. Earthquakes generate elastic disturbance (waves), which propagate from a point outwards through the interior zones of the earth. Depending on their associated energy and trajectories, these disturbances are capted at variable distances from the source (Focus). The seismic method utilizes the propagation of an elastic wave through the earth, which depends upon the elastic properties of the rocks [16]. At the processing center, the data analyst converts the field data from the field records to a time section, giving the best possible picture of the surface [4]. Noise in seismic prospecting is resembled by the unavoidable presence of unwanted signals in the seismogram or seismic record.

2. Types of Seismic Noise

2.1. Coherent noise

Coherent noise consists of organized unwanted signals that appear on seismic records when the source is applied. Common types of such noise are surface waves, ground roll, airwaves, refraction, and multiples. Coherent noise can be removed by geophone-and hole-array field arrangements or filters [11,12].

2.2. Incoherent Noise

Not generally source generated, the noise would be present whether we shoot or not, e.g. random, microseisms, falling debris, wind, traffic. It is unpredictable and can be made up of a wide band of frequencies (white noise) which is difficult to remove by filters completely. As discussed later, stacking is the most effective way to filter random seismic noise. Multiples:-Seismic energy, which travels from source to interface and is then reflected by a detector, produces a primary reflection. Multiple reflections are produced if the energy is reflected more than once in its path to the detector. Multiples arise when there are interfaces with large reflection coefficients, i.e. where there are large velocity and density changes [17].

3. Objectives of the Present Study

The objectives of this study are to enhance the signal and reject the coherent and incoherent noise while producing a seismic section representing the subsurface structures.

4. Methodology

The data used in this work includes seismic raw data of 2D. The project contains six lines of 2D, about 132. km long, Acquired by BGC using dynamite as an energy source and 248 receivers spread and record length of 7 seconds at 2ms sampling rate; coordinate elevation and static corrections information was provided in CD -ROM. for lines. The agreed datum plane is 400 meters above mean sea level. We are using Grisys Software for processing. We loaded the data into our System and reformatted it to 2m sec, and then geometry correctly represented the sources, receivers, X files and static of S, R and fold. We apply amplitude compensation and spherical divergence to compensate for the loss of energy using this equation T*V2 (T). Likewise, we removed bad trace, misfired shot, open channel and noisy traces. It is an interactive method for picking bad traces and defining the editing window. In the noise attenuation stage, we applied Bandpass filters, adaptive subtraction and high amplitude techniques to attenuate the noise available in this data, such as ground roll, Linear noise, High amplitude noise and multiples. Likewise, we apply deconvolution and stacking for random noise eliminations, Velocity analysis is applied using interactive software to pick velocities every half, and one Kilometer and residual static is applied to eliminate time shift caused by inhomogeneous shallow structure, to remove the variations in sources and receivers and place them to the datum plane to get optimum stack section. Post stack migration was applied to remove diffractions and better focus the fault positions.

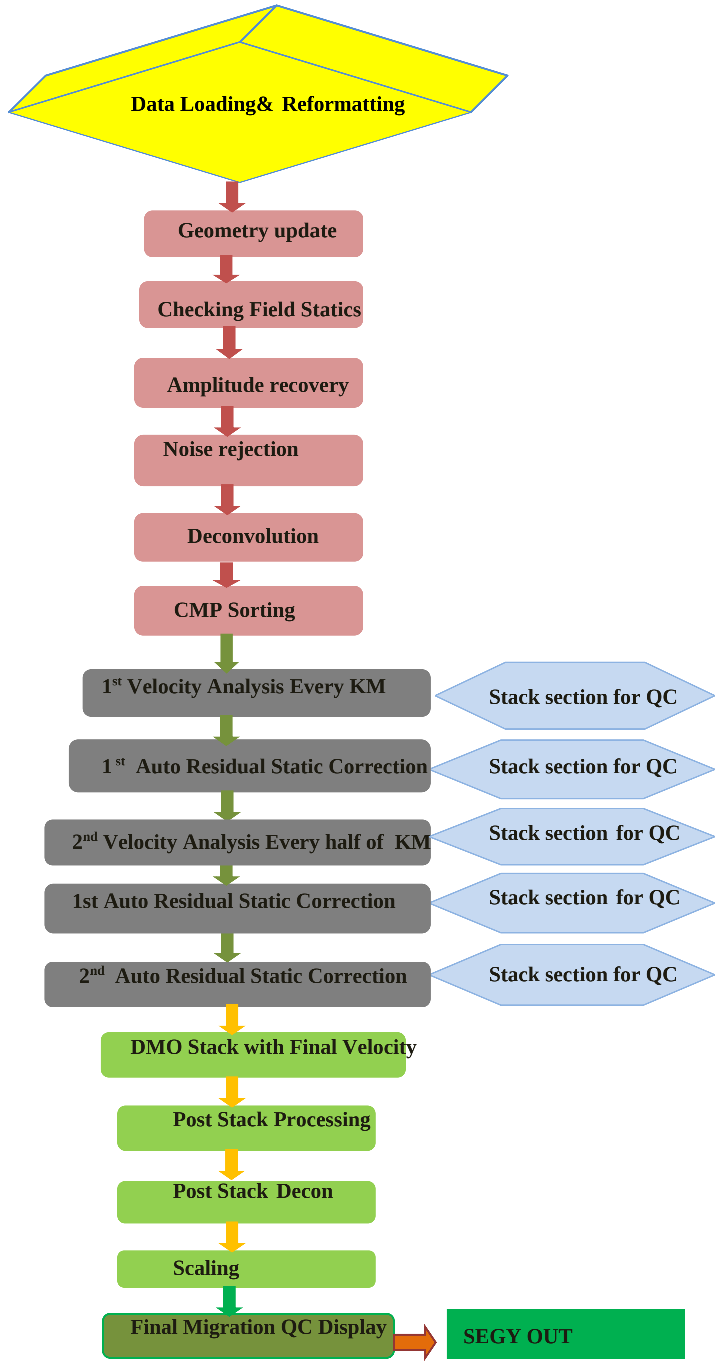

Fig. 1 seismic data processing sequence

5.1. Processing Parameters

Testing parameters is a logical sequence of discrete jobs designed to provide the optimum parameters to apply to all data in seismic processing. Parameters are tested on a predefined testing area, and decisions on the choice of parameters for production are made based on the results of these tests. There are two types of parameters: the first is prestack parameters that include mute test, filters, noise attenuation, and deconvolution tests. The second post stack parameters include zero phases, deconvolution, filtering and equalization tests.

5.2. Raw Shot Display

Contains reflections, refractions, ground roll, linear noise, airwaves, amplitude losses of the frequency with time, direct arrival, diffraction etc. (Fig. 2).

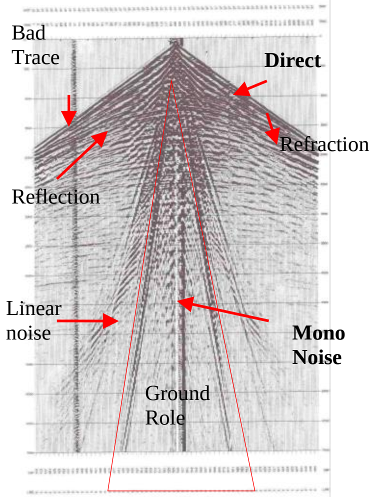

Fig. 2 Raw shot record contains types of noise

5.3. Amplitude spherical divergence compensation

This step is applied to compensate for the effect of geometrical spreading by multiplying each sample, E (t), By the product T*V2 (T). The amplitude compensation module removes the trace energy differences resulting from the source and receiver.

Where

E(t) is the sample value

T is the travel time between the source and the geophone.

T_o is the zero offset travel time and.

V is the zone velocity for the CDP taken into account.

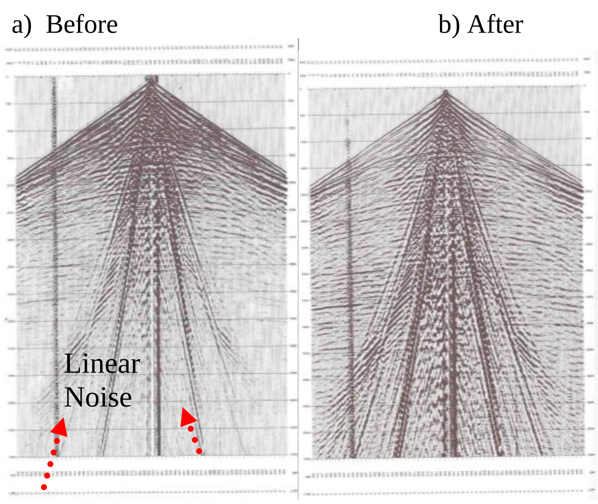

Fig. 3 Amplitude Spherical divergence compensation

5.4. Manual editing of trace

Removing bad trace, misfired shot, open channel and noisy traces. It is an interactive method for picking bad traces and defining the editing window.

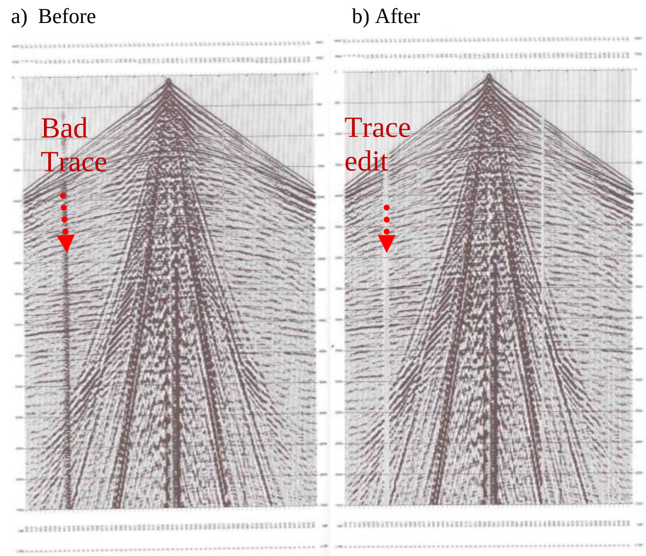

Fig. 4 Manual trace editing

5.5. Removal of Ground Role using Frequency filtering

Ground roll is source generated; it has low velocity, low frequency and high amplitude [2,5, 13]. [23], Ground roll is composed of Raileigh waves, which are vertical components. [3], filtering is a selective deletion of information passing through a system and, unless otherwise specified, indicates discrimination based on frequency. This is a useful approach in processing since signal and coherent noise (and some random noise) often have different, albeit possibly overlapping, spectra. Therefore the signal is defined in the present context as that which falls within the desired frequency band, and noise as anything outside that range (Fig. 5).

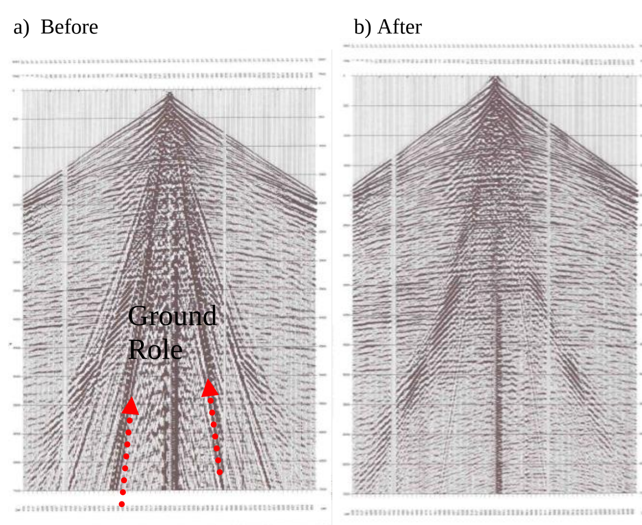

Fig. 5 High Freq pass filter and removal of the Ground role

5.6. The Removal of Linear Noise before Stacking

This eliminates the linear coherent noise on the shot gathers before stacking. The method is applied to the whole record rather than small windows containing coherent noise. The elimination is done in the t-x domain, and the coherent noise is detected automatically.

a) Before b) After

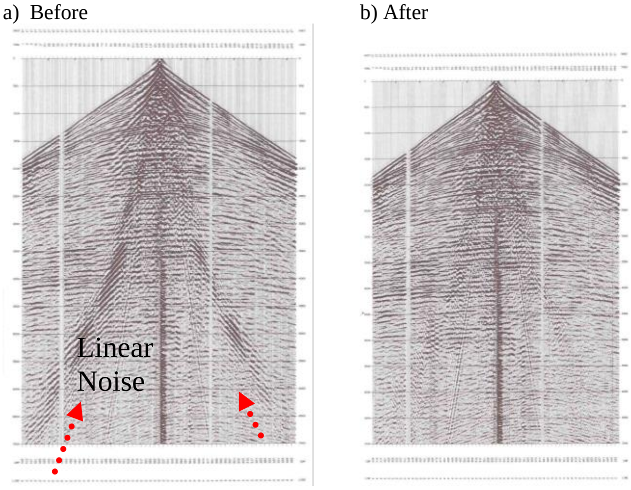

Fig. 6 Removal of Linear Noise

5.7. High amplitude noise elimination

This method detects and eliminates the high amplitude noises in seismic data. Attenuation the high amplitude noise, such as ground roll and multiples. The final subsurface image may provide the wrong information for the interpretation without attenuating this high amplitude noise. This paper successfully implemented two techniques to attenuate coherent and in coherent high amplitude noise [6]. For incoherent high amplitude noise attenuation, we use the strategy that the detected frequency components contaminated by strong amplitude noise are recovered by using a filter. For coherent high amplitude noise attenuation, we use the strategy that first estimates the coherent noises and then adaptively subtract them from the data using a pattern-based adaptive subtraction technique. [6].

a) Before b) After

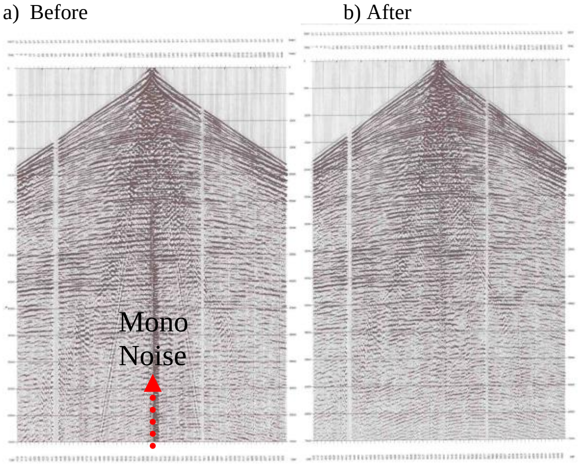

Fig. 7 High amplitude noise elimination

5.8. Deconvolution

In the time domain, deconvolution involves finding an inverse of the wavelet, which outputs the reflectivity series when convolved with the seismic trace. Deconvolution in the frequency domain involves estimating the inverse of the amplitude spectrum of the wavelet and multiplying the amplitude spectrum of the seismic trace by this inverse spectrum multi traces. The following four domains are considered: source, receiver, CMP and offset or CMP and offset. The term deconvolution is most often applied to a type of inverse filtering [8]. The desirable result can be obtained even if the wavelet is not of the minimum phase, such as vibroseis records [21].

a) Before b) After

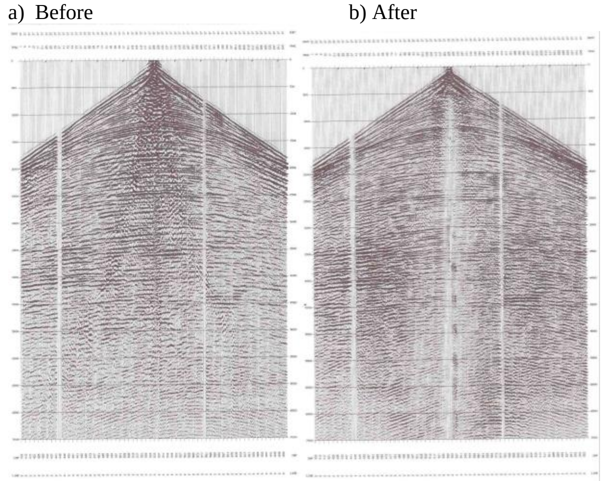

Fig. 8 Deconvolution enhanced signal-to-noise ratio

5.9. NMO (Normal Moveout) Velocity and velocity analysis

Velocity is the speed with which an elastic wave propagates through a medium. For non-dispersive body waves it is usually assumed to increase with increasing depth. When measured in a vertical direction, it may be lower than measured parallel to strata. [1, 20]. The variation of reflection arrival time is due to variation in source-receiver offset. This variation in arrival time is hyperbolic on a CMP gather

a) b) c) d) e) f)

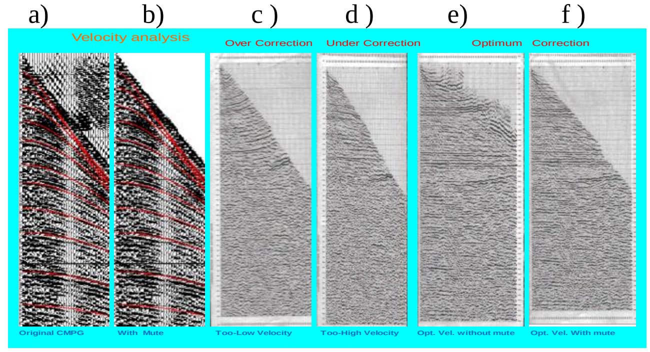

Fig. 9 Shows the cases of velocity during picking (a) CMP gathers without mute, b) CMP gathers with mute, c) over low correction velocity, d)) under correction high velocity, e)optimum velocity without mute, f)optimum velocity with mute applied.

a) Before b) After

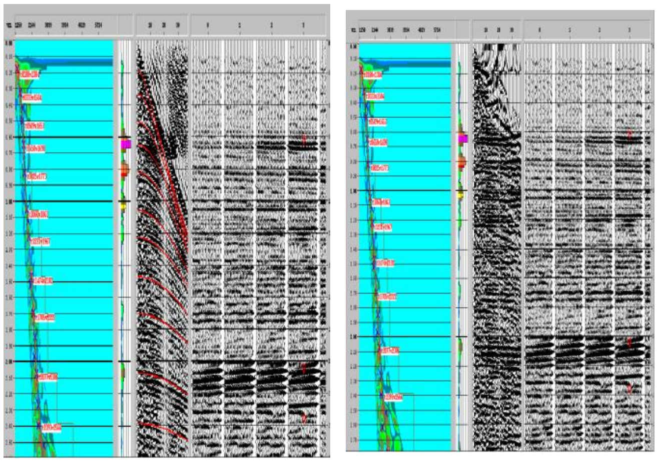

Fig. 10 Velocity Analysis a&b) showing spectrum, CMP and sack Panels

5.10. Brute Stack Section

To inspect the correctness of pre-processing and quality control, seismic data after static datum correction was sorted to CDP gather to do brute stack and display several sections in both X and Y directions.

a)

Fig. 11 a) brute stack section

b)

Fig. 12 b) velocity stack section

5.11. DMO STACK

This module computes and applies DMO corrections to NMO corrected pre-stacked trace using a time domain integral method and sums belonging to the same CDP. Full DMO stack.Aperture dip max: 45 degrees, DMO Velocity Effects of layer's dip were eliminated after DMO so that DMO velocity may describe true layer information.

5.12. Migration

According to [22], Migration is the process that moves the data on our stacked seismic section into its correct position in space and time and restores diffractions. Post stack time migration was applied for all the lines in this project. A full-aperture Kirchhoff Migration smears the event energy to all possible subsurface points in the model space for migrating a single event on a single trace. After smearing all samples on all traces, a Kirchhoff image is obtained by stacking all individual contributions. The Kirchhoff algorithm compensated both the obliquity factor and the geometric spreading factor [25]. Seismic Migration is the one most directly associated with the notion of imaging. Until the migration step, seismic data are merely recorded traces of echoes, waves that have been reflected from anomalies in the subsurface. In its simplest form, seismic Migration is the process that converts information as a function of recording time to features in subsurface depth. Rather than simply stretching the vertical axes of seismic sections from a time scale to a depth scale, Migration aims to put features in their proper positions in space, laterally and vertically [9]. Seismic Migration is a set of techniques for transforming recorded (elastic-wave) seismic reflection data into an image of reflecting boundaries in the earth's interior. [10]

After Migration, diffractions are converged correctly, and fault plane waves are moved to their true position so that small faults and fault points are clear, and at the same time, the positions of faults and the structures are right. The results of processing and final Migration Seismic sections of dip lines Figures 15 and 16 from the study area can be structurally transformed to produce restored seismic sections showing the subsurface geology of the past. Here we can see only normal faults. The basin form in this section is graben starting from 400 ms to 2600 ms (the zone of the interest area).

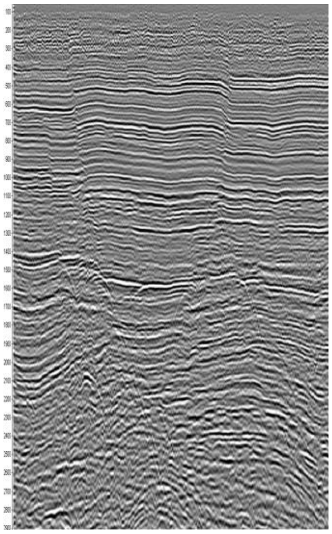

Fig. 13 migrated stack section

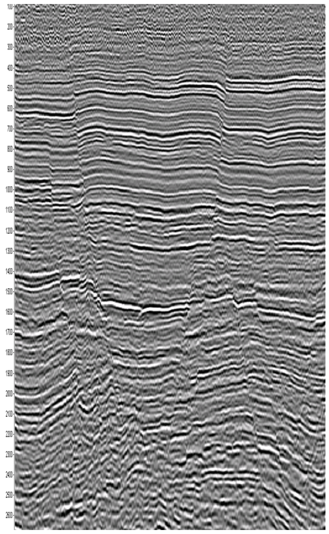

Fig. 14 migrated stack section

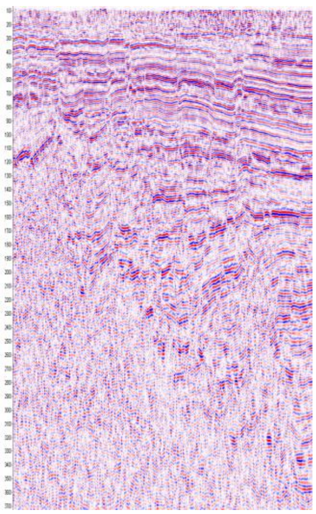

Fig. 15 migrated stack section

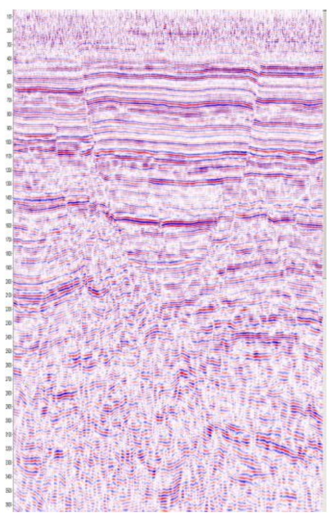

Fig. 16 migrated stack section

6. Conclusion

The processing work has fulfilled the following objectives:-

- Enhancing the signal–to–noise ratio (S/N) in the zone of interest.
- Reflection resolution improvement is well achieved in the 2D section.
- Subsurface reflection has been clarified.
- with migration application, the perfect collapse of diffractions and good fault resolution results.
- Coherent and Incoherent noise are removed.

7. Acknowledgements

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