

THE USE OF F-K FILTER IN THE ELIMINATION OF ARTEFACTS FROM A SHALLOW SEISMIC REFLECTION DATA IN ZARIA, NIGERIA.

C. C. COLLINS AND I. B. OSAZUWA

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ABSTRACT

Near surface high resolution 2-D seismic reflection survey was carried out along the Zaria batholith. Zaria area forms part of the Precambrian basement complex of north central Nigeria which comprises Precambrian rocks made up of granite, gneiss and Low-grade metasediments. The granitic Zaria batholith intruded the gneiss and metasediments which forms the country rock. Reflection signals from shallow seismic survey in this area are often marred by surface waves, refraction and multiple reflections. The processing of the seismic data if not well handled often leads to migration artefacts which could be misconstrued as a seismic event.

The field procedure employed for the geophysical survey was the split spread mode. The geophones were fixed at an interval of 1m, and a constant offset of 0.5 m. The common depth point method (CDP) with 12 fold coverage was adopted for the survey.

Several artefacts were noticed on the result of the seismic migrated section, when the fk filter was initially applied only on the pre-stacked seismic data. The filtering and the common midpoint stacking could not completely eliminate the seismic noise on the pre-stacked seismic data. However, when an fk filter was applied on the post-stacked seismic section, the remaining seismic noise that survives the initial processing flow was eliminated. When migration was carried out on the filtered post-stack seismic section, the resulting seismic section was free from artefacts, and showed clear seismic events.

KEYWORDS: f-k filter, artefacts, shallow seismic, reflection, migration. Zaria

1.0 INTRODUCTION

1.1 f-k filter

Most of the time, it is difficult to separate the reflections from noise. This separation can be made easier when the data is not processed in space-time domain, but transformed into another domain.

1.1.1 What is f-k?

The f-k transformation is in principle a two-dimensional Fourier transformation. Corresponding to the transformation of the time-axis to the frequency domain,

the x-axis is transformed to the wavenumber domain.

The frequency indicates the number of oscillations per second. The Wavenumber k indicates the number of wavelengths per meter along the horizontal axis (Some authors define k as the number of wavelengths per meter along the horizontal axis times 2π). For waves which propagate horizontally, the transformation returns the actual wavenumber. For waves that do not propagate horizontally, the horizontal component of the wave is transformed.

An apparent wavelength and an apparent velocity are obtained:

$$v_a = \frac{v}{\sin \alpha}$$

$$\lambda_a = \frac{\lambda}{\sin \alpha}$$

With α =angle of the wavefront with the interface (or the angle of the ray with the vertical).

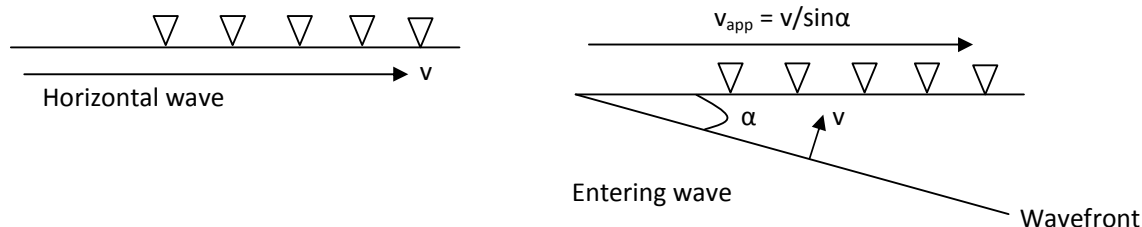


Figure 1: Velocities of Horizontal waves and entering waves

C. C. Collins, Physics Department, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

I. B. Osazuwa, Physics Department, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

Reflections that travel vertically reach the geophones at the same time and therefore have an infinite apparent velocity. The relation between the frequency and the wavenumber is given by: $f = v_a k$, i.e. the slope of a line in f-k domain is the apparent velocity v_a .

It is apparent that different types of seismic event fall within different zones of the f-k plot and this fact provides a means of filtering to suppress unwanted events on the basis of their apparent velocity. The normal means by which this is achieved, known as f-k filtering, is to enact a two dimensional Fourier transformation of the seismic data from the t-x domain to the f-k domain, then to filter the f-k plot by removing a wedge-shaped zone or zones containing the unwanted noise events, and finally to transform back into the t-x domain. An important application of velocity filtering is the removal of ground roll from shot gathers. This leads to marked improvement in the subsequent stacking process, facilitating better estimate of stacking velocity and better suppression of multiples. Velocity filtering can be applied to portions of seismic record sections, rather than individual shot gathers, in order to suppress coherent noise events evident because of their anomalous dip, such as diffraction pattern (Kearey and Brooks, 2002).

A stacked seismic section is a composite record made by combining traces from different records. Example, a common midpoint stack, is a stack of common midpoint gather traces (Sheriff, 2002). A seismic section is referred to as pre-stack seismic section, before carrying out the process of stacking, and is referred to as post-stack seismic section after the process of stacking has been applied.

Reflection event has a range of apparent velocities from infinity, at $x=0$ for vertical arrivals with horizontal wavefronts, down to the limiting stacking velocity, where the arrivals run parallel to a direct or refracted event. In the case of the first reflection, they will become asymptotic to the direct wave with an apparent velocity of v (Brian, 2000).

Frequency-wavenumber (f-k) noise attenuation algorithms work well for attenuating coherent source-

generated noise (including multiples) as long as the data are well sampled spatially (Alistair, 2004).

The aim of this work is to outline the techniques involved in the application of f-k filter on a post-stack data, to eliminate artefacts, which could not be completely eliminated by its application on a pre-stacked data and the use of common midpoint stacking.

1.2 DATA ACQUISITION

The 2-D seismic reflection data was acquired by putting the source and the receivers in a straight line. The split spread mode of coverage was employed for the survey. The receivers were placed symmetrical on both sides of the shot at a constant interval of 1m. A constant offset of 0.5m from the right receiver and the left receiver was used throughout the survey. The energy source was a 50kg sledge hammer. After each shot the first receiver on the spread is taken ahead of other receivers, the connections to each of the take out were then swapped in the direction of the increasing profile, the source was then moved 1m, before taken another shot. The resulting seismogram from each shot was recorded. And each of the points was sampled 12 times, for the 12 fold coverage, resulting from the 24 channel seismograph.

1.3 DATA PROCESSING

The first step in the data processing was the edition of the recorded seismic raw data reflection geometry, and the muting of the bad traces. Static correction was then applied to take care of the elevation and the low velocity layer. The next step in the processing flow was the application gain, to enhance the amplitude of the reflection signal. An f-k filter was then applied to the pre-stack data to get rid of every undesired onset (surface waves, refraction and multiple reflections). Semblance analysis was then carried out on the sorted common midpoint data to generate a 2-D velocity model. This velocity model was used for stacking, to produce the stacked seismic section (Fig.2).

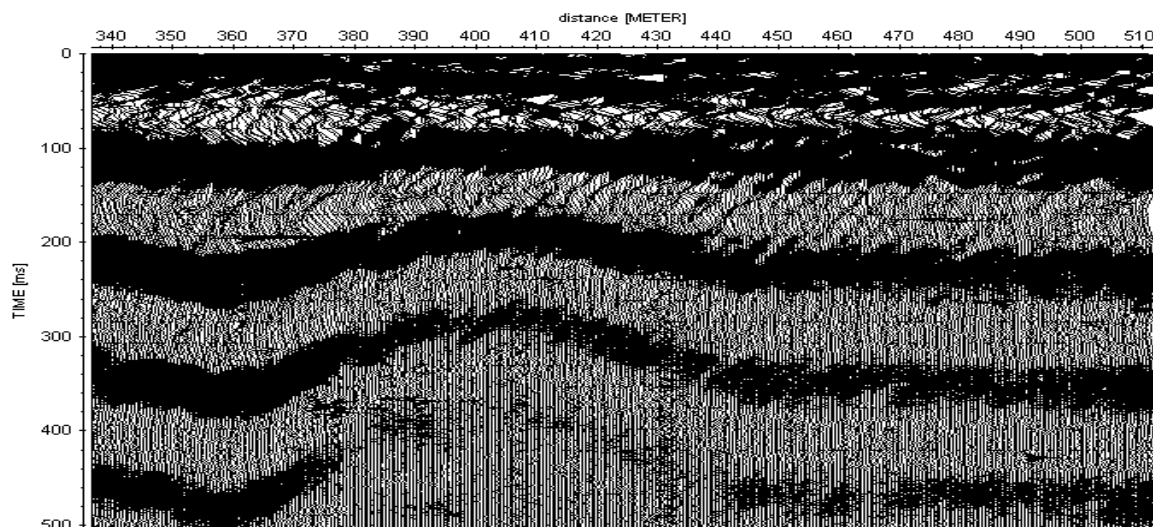
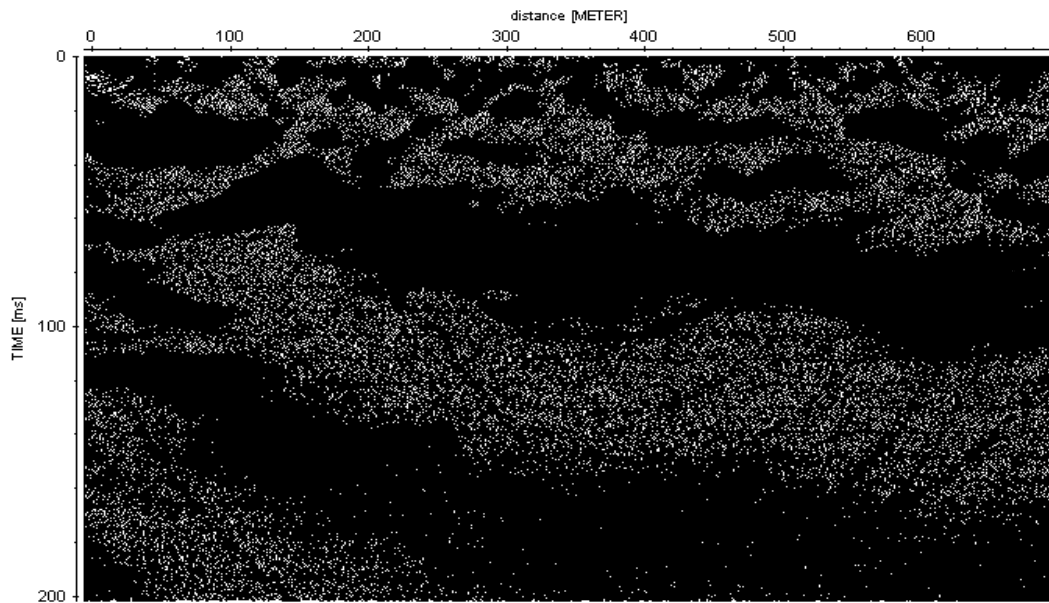


Figure 2: Part of the stacked unmigrated seismic section

The stacked section was then migrated in time, to produce a seismic migrated section (Fig. 3). Another seismic reflection profile collected in the same area was

stacked and migrated in time, which also showed sign of migration artefacts, was displayed in wiggle mode and in an enlarged section in wiggle mode (Fig. 4).



Artefacts

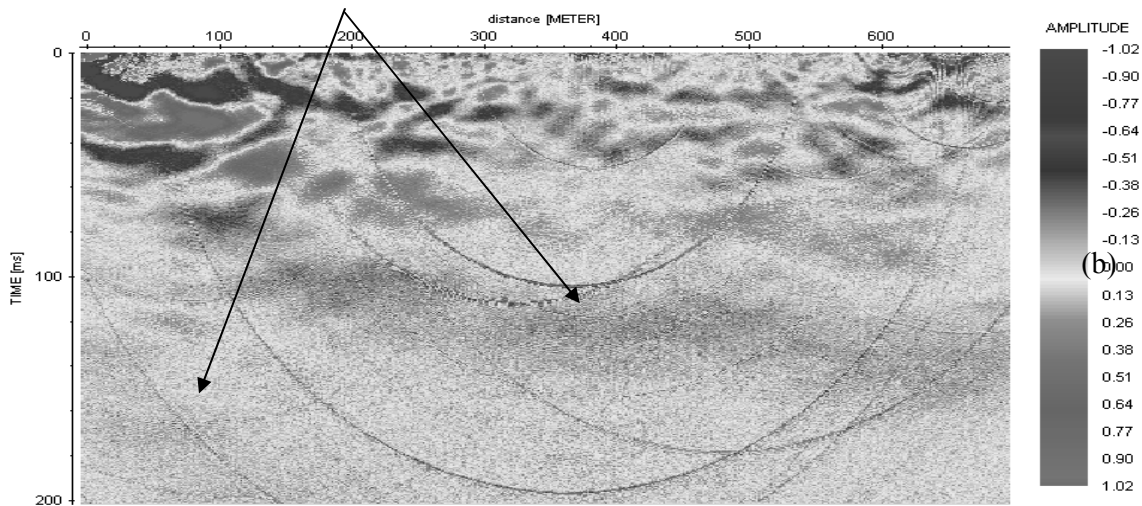


Figure 3: Post-stacked Migrated seismic section in time (a) Displayed in wiggle mode (b) in pointmode

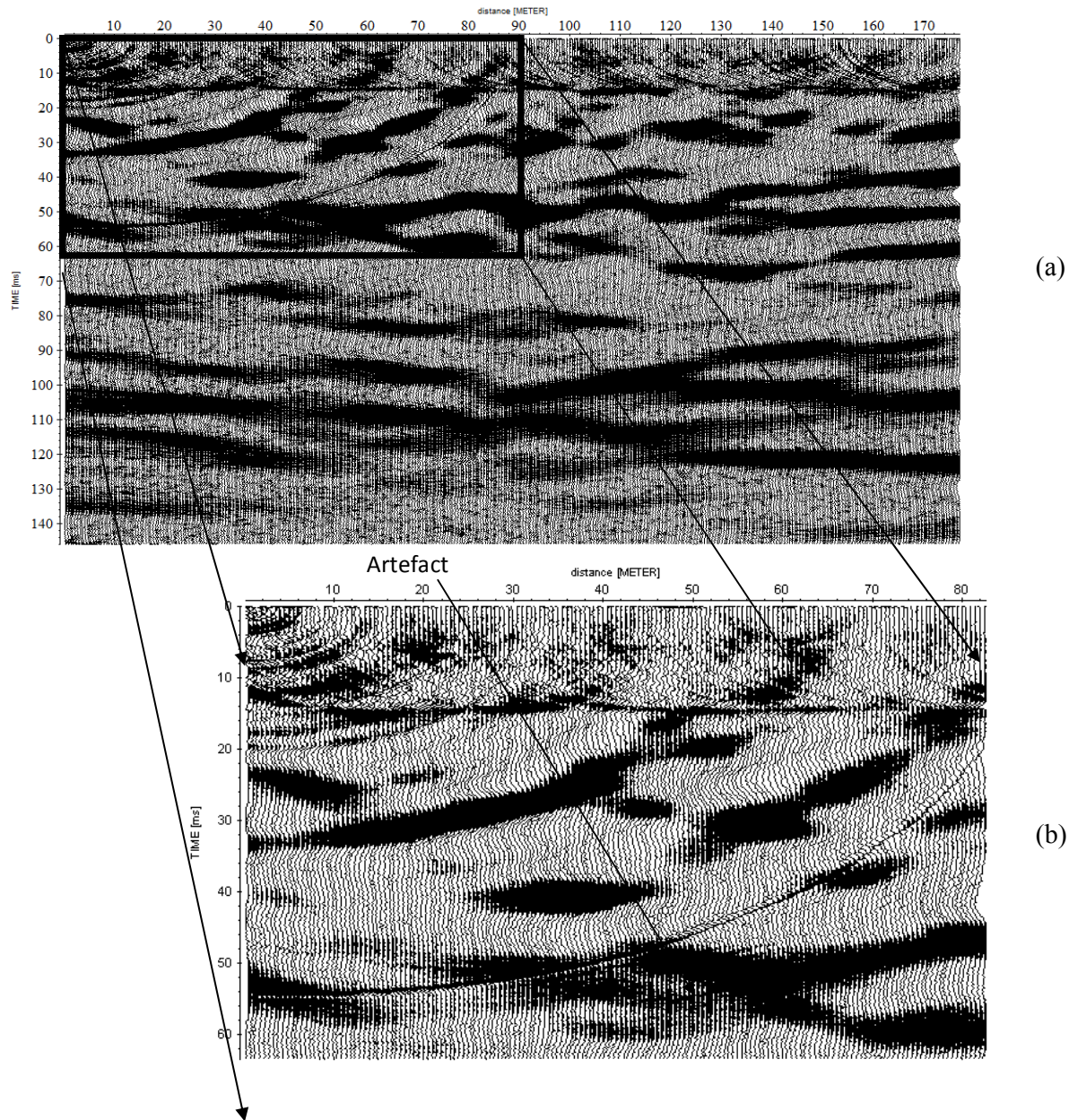


Figure 4: Another seismic profile taken in the same area (a) Section displayed in wiggle mode
(b) Section enlarged in wiggle mode

1.4 RESULTS AND DISCUSSION

The processing carried out on the seismic data resulted in the production of a stacked and migrated seismic sections. However several bow shape migration artefacts were noticed on the migrated seismic section. This was as a result of the fact that Migration assumes that all data represent primary reflections or diffractions. Migration smears out noise and the quality of a final migrated section strongly depends on how much noise was present in the unmigrated data (Robert et al, 1999). The artefacts noticed on the migrated seismic section (Fig 3 and 4), was an indication that the f-k filter applied on the pre-stacked seismic data and the process of the common midpoint stacking could not eliminate the

seismic noise completely. Hence a second f-k filter was applied on the post-stack data after careful determination of the frequencies and apparent velocities of the reflections signals to eliminate the artefacts. When the post-stacked data was migrated in time after the application of the f-k filter, the artefacts was removed from the stacked seismic section, leaving only the primary and the diffracted seismic signal that form the true reflection event (figure 5 and 6). The artefacts that survived the filtering are those that were asymptotic the reflection signal, and any attempt to completely remove them will lead to non preservation of the true amplitude of the reflected seismic signal.

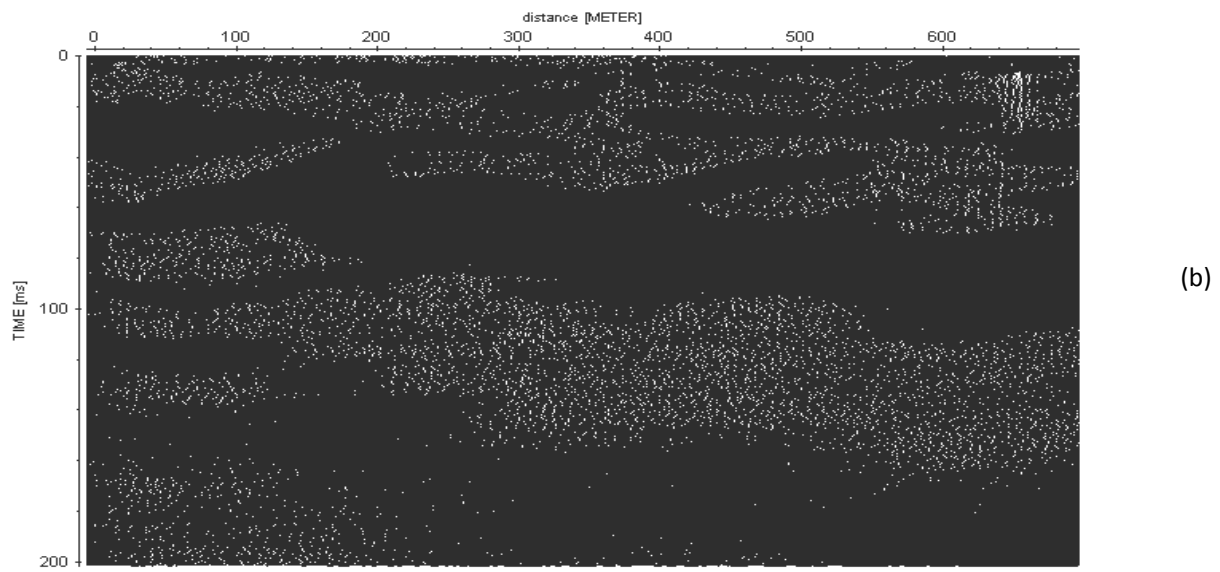
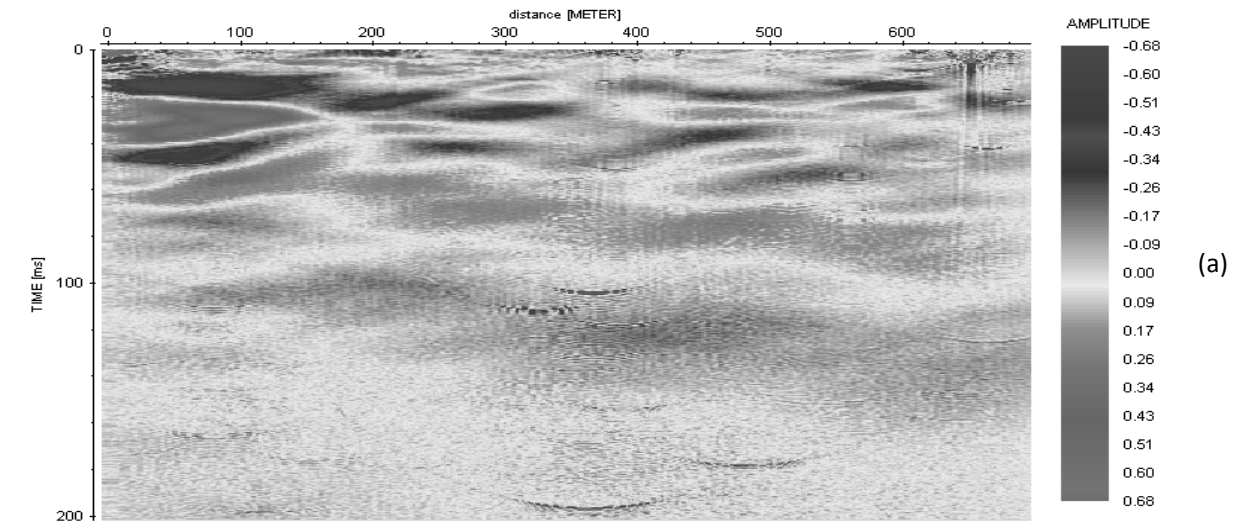
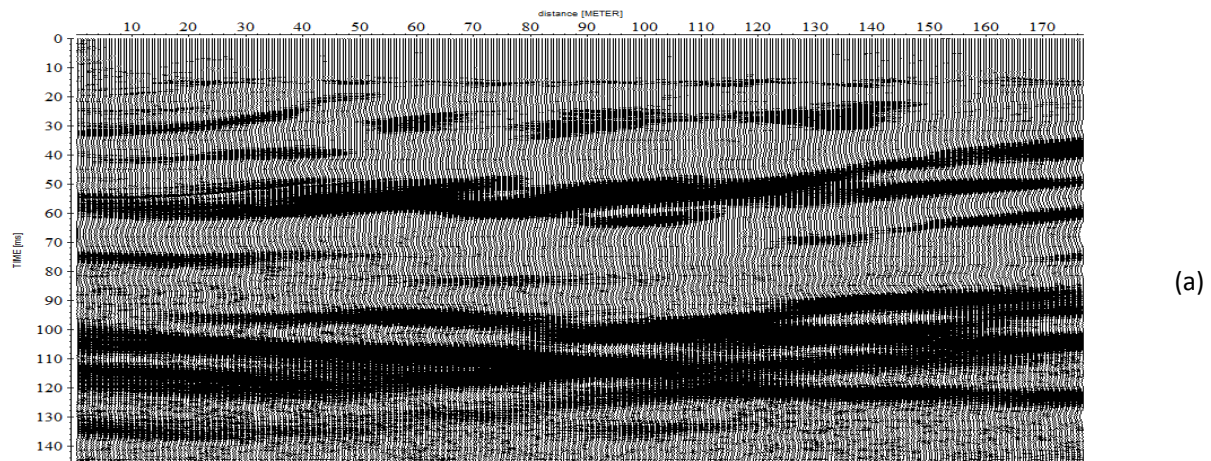


Figure 5: Post-stacked seismic data of figure 3a after application of f-k filter (a) displayed in point mode and (b) displayed in wiggle mode.



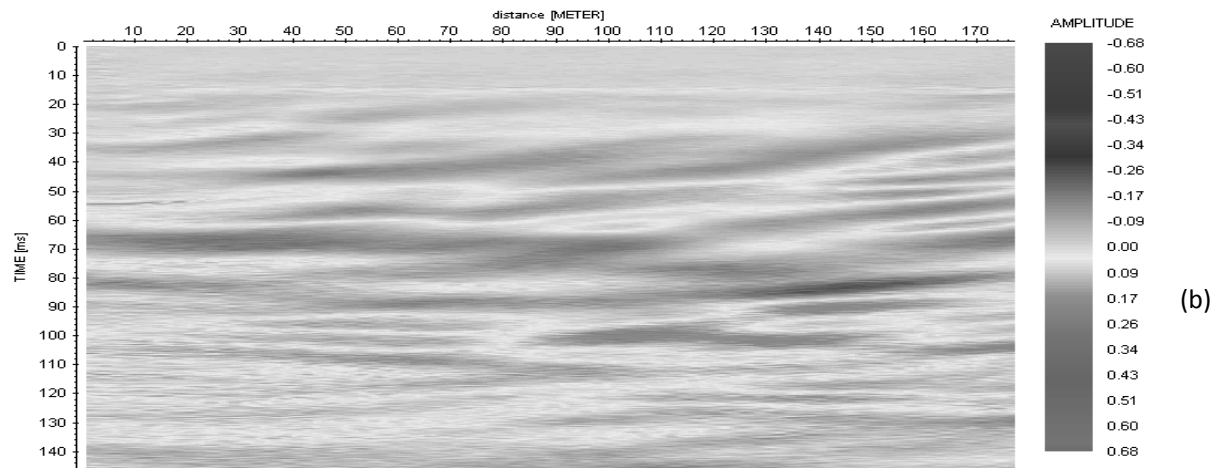


Figure 6: Migrated Post-stacked seismic data of figure 4a after application of f-k filter (a) displayed in point mode and (b) displayed in wiggle mode.

1.5 CONCLUSION

This research work has shown that it is possible to eliminate migration artefacts that escaped the application of the f-k filter in the pre-stacked and common midpoint stacking from seismic section by the application of f-k filter on a post-stacked seismic section. However it has to be done with caution to avoid damaging the true amplitude of the seismic traces, because at long offset in a time distance curve plot, the reflection event becomes asymptotic to the direct wave (becomes almost equal to the direct wave). A good example is the reduction of the clarity of figure 5a and b, since the quality of their amplitude was reduce by the application of the f-k filter, hence the filtering has to be applied in stages to preserve the best amplitude quality. There has to be a tradeoff between complete removal of artefacts and the quality of the amplitude.

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