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Applied NMO Correction to Seismic data (Dynamic Correction) Consider 2D Model case

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Abstract The main objective of exploration seismology is obtaining structural subsurface information that may indicate possible hydrocarbon reservoir after proper interpretation. Reflection seismic survey is a dominated method for determining the subsurface structure during hydrocarbon exploration. Sedimentary layers have faults, anticlines, folds, and unconformities which are in fact the very features that trap petroleum are the targets of the seismic exploration program in the first place. Most important physical parameter method for determining an accurate image of the subsurface, is velocity of the geological medium. Thus the velocity depends on the subsurface, its physical state (whether solid, liquid, or gas). Howevere, it is not that easy to obtain a good velocity model. This is often an iterative process. This paper will be concentrated on one of three major techniques of seismic processing is namelly Normal moveout (NMO), which is one of the cores of the stack technique. The procedure for eliminating the effcet of offset to the traveling time of reflected wave. The using data is 2d model case.

Key word: Dynamic Correction – Model Case.

تطبيق التصحيحات للبيانات السيزمية(التصحيح الديناميكي) نموذج حالة 2D

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الملخص إن الهدف من الاستكشاف السيزمي هو الحصول على معلومات حول التراكيب تحت السطحية، والتي يمكن أن تنبأ عن تواجد الهيدروكربونات في حال إن كانت التفاسير صحيحة. ويعتبر المسح السيزمي الانعكاسي السائد في تحديد التراكيب التحت سطحية خلال مراحل استكشاف الهيدروكربونات. حيث أن طبقات الصخور الرسوبية تحتوي على الصدوع والطيات والحنائر وكذلك عدم استمرارية الطبقات، وهي جميعها بيئات واعدة لاحتجاز الهيدروكربونات وبالتالي تعد هدف أساسي للاستكشاف السيزمي. حيث أن المتغير الفيزيائي الأهم في تحديد نماذج (قطاعات) للطبقات التحت سطحية وبدقة، بالطبع سرعة تلك الأوساط، وعليه فان السرعة تعتمد على خواص حالة الأوساط الطبيعية (صلب-سائل – غاز). إلا أن إيجاد نماذج دقيقة للسرعة، ليس بالأمر اليسير. حيث تعتبر عملية تكرارية. وعليه فإن الأسلوب المستهدف للدراسة في هذه الورقة يركز على أحد أهم ثلاثة تقنيات للعمليات السيزمية ألا وهو عملية التكديس (الجمع) حيث أن مفهوم الإزاحة الجانبي والمعروف اختصار (NMO) يعتبر جوهر تقنية التكديس، والهدف منها هو إزالة تأثير المسافة الفاصلة بين مصدر الطاقة والجيوفون (الاوفست) لازمنة انتقال موجات المنعكسة. باستخدام نموذج (نمذجة) D2.

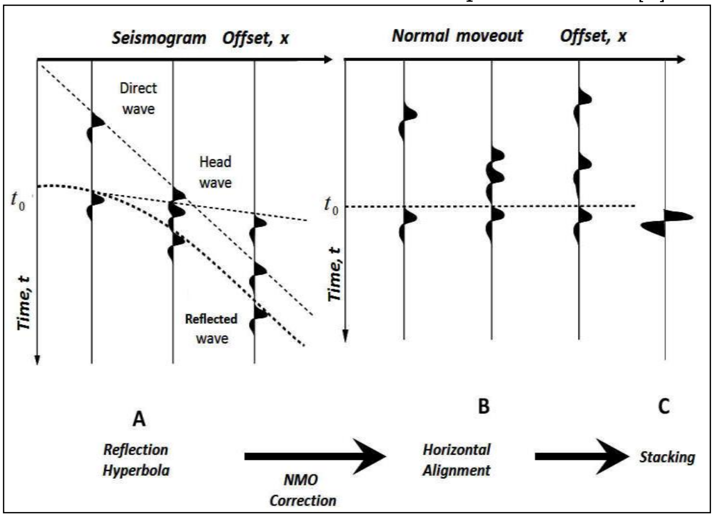
الكلمات المفتاحية: التصحيح الديناميكي – حالة نمذجة.

Introduction

The major task of seismic exploration is to develop models of the subsurface and methods of data processing which can be used to interpret the complex wave front arrivals on a typical seismogram. One of the main goals in seismic data processing is to estimate seismic velocities of geological structure in the earth. In seismic processing we are going to manipulate our measured data in time, to have an accurate image of the subsurface. The link between time and depth is, of course the wave velocity that varies within the earth from position to other. The aim of this paper is to obtain the desired information, First we will discuss some simple models in order to understand the features. which have to be applied in real data. NMO correction is usually considered in a hyperbolic equation where $t(x)$, is travel time, related to the (x), offset between the source and the receiver, (t_0) two-way zero offset travel time, (V_{nmo}) is (NMO) velocity which estimates the root mean square (RMS) velocity in a case of horizontal stratified earth [11]. Regarding to figuer (1), when the (Δt) is calculated as shown in equation (2) , the effect of offset on the arival time of wave could be eliminate after the process of (NMO). By stacking all the seismic data of the receivers after (NMO), a specific stack for common midlle point (CMP) is obtined. Therefore seismic data could be stacked in phase.

A characteristic of seismic data as obtianed for the hydrocarbone exploration, is that generally show a poor Signal to Noise ratio (S/N). An important goal in seismic processing is to enhance the (S/N) ratio, and the most important steps to achieve this goal, is CMP (common mid point) sorting and stacking

[1]. The summation of signals from a several of similar input channels for the purpose of increas the (S/N) ratio is known as stacking. With stacking we add the (NMO) traces in a (CMP) gather to have one output trace, this means with stacking, we reduce the data volume. The amount of data reduction is the number of added traces in CMP gather. The idea behind this procedure as shown in Figure (1) the purpose of stacking was originally suggested by [2]. Stacking the signals will not only produce a high quality reflection signal in relation comparing to background noise, but also has proved to be useful for reducing the signals from multiple reflections [3].



Fig(1). Principle of NMO correction.

From Figure (1). the reflection is alignment using proper velocity,such that events are horizontally, and at the last step all the separate traces are summed (stacked)

Normal Moveout correction (Back ground theory)

The main task of data acquisition in the field is to record seismic signals at the surface of the earth in time, and obtain an accurate image of the subsurface in depth. And as mention above the link between the time and the depth is the velocity of sesimic wave, which varies in the earth from position to position (considering the earth is not homogeneous). Single channel profile systems give a display which is directly in the form of seismic section of a closely spaced individual seismogram (trace) as shown in figure (2) but multi-channel data of common depth point type have to undergo steps of corrections (sismic processing sequence) before producing the seismic section. In this case one of the particular important corrections is know as dynamic or Normal Moveout Corrrection (NMO) [4]. After a corrections so called static corrections has applied to seismic data before the NMO correction was performed, then the seismograms are next rearranged by computer from the (common shotpoint) , in which they are arranged on digtal tape to give one output trace. In general, corrections need to be done before to further data processing [5].

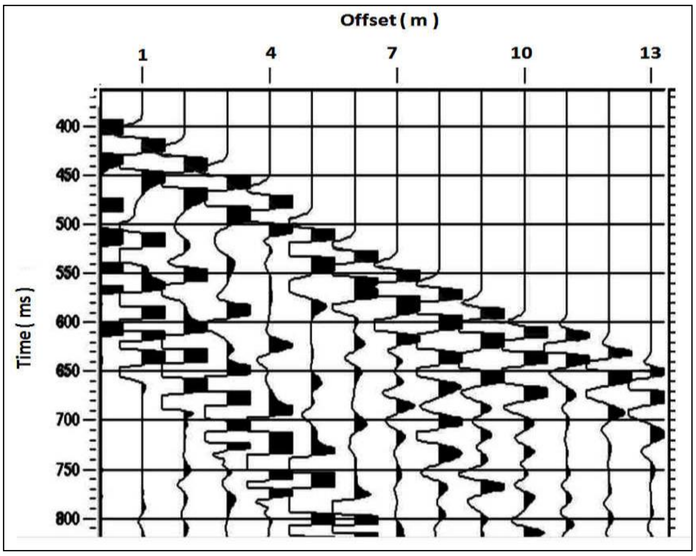


Fig. (2) Indivadual seismogram (synthetic trace).

A method of getting the advantage of combining data without smoothing, it's the Common Depth Point (CDP). The principle of (CDP) is quite simple. Asource and geophone gather subsurface data directly beneath the mid point (CMP) of the shot reciver separation. But for multi-channel data the other source is placed farther from the center, and the geophone is placed at an equal distance on the other side Figure (3), when energy from the second source is recorded at the second geophone, subsurface information will be from the same center point. So energy traveling by two paths gives information on the same point, and so on. Part of the longest path can be subtracted to make it the same length as the other. In practice (CDP) is not so simple, as described, the various energy paths are sorted out later in data processing step for correction and put together of set of paths that have the same depth point to make a single stacked trace (the word stack is usually reserved for the combining of traces after correction, during data processing [10]. In digital processing, the amplitudes of traces are expressed as numbers, so stacking is accomplished by adding those numbers together [6].

Stacking can be used to combine two or more adjacent traces into one, so they can be treated as one trace in processing, to reduce the amount of processing required for a large number of traces, combination takes place in several ways, and for several purposes [6]. The most common use of stacking is the combing of traces in common depth point processing [6]. The purpose for applied stacking, is to test the accuracy of the NMO corrections, and determine seismic velocities in the subsurface.

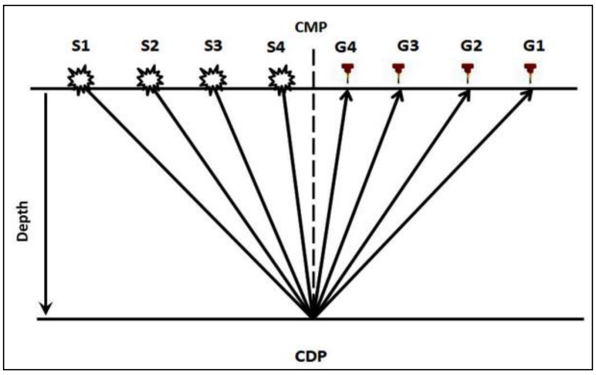
Time – Distance Equation:

The Normal Moveout Correction for the homogeneous structure is obtained from the hyperbolic relationship between traveltime and half-offset. The mathematical representation of the travel time (t) for a geometrical ray from source to receiver, For offset distance of (x) the reflected wave, for single interface referring to Figure (4), can be written, based on the Pythagoras theory as

$$t^2 = t_0^2 + \left(\frac{x}{V}\right)^2 \text{ ....(1)}$$

The vertical travel times or zero offset (TWT) across each layer is.

$$t_0 = \frac{2h}{V}$$



Fig(3). The geometry of (CDP) technique in horizontal Reflector

Where (t) is the reflection travel-time with x the source-receiver offset, (t_0) is the normally incident reflection time at the midpoint between source and receiver, (h) is the reflector depth, and (V) is the velocity. For a multi-coverage seismic survey, the $(t-x)$ equation of each trace in a common-midpoint (CMP) gather can be written as equation (1) [2]. When the observing surface is not flat, the reflection travel-time changes with the elevations of source and receiver stations. Where the medium (layer) above the reflector has a constant velocity (V) which can be determined by using the most straightforward method for determining velocity and thickness was first proposed by [7]. which, refered to as $(t^2 - x^2)$ method. By ploting (t^2) against (x^2), the reciprocal slope can be used to determine (V^2) as illustrated in figure (5), in appropriate estimation of velocities sequentially results in a false indication of subsurface structure [8], figure(9). The square root returns the proper velocity. such plotting is useful for individual seismograms but cannot be incorporated into a continuous production routine [3].

$$\Delta t = (t - t_0)$$

$$\Delta t = \left(t_0^2 + \frac{x^2}{V^2}\right)^{0.5} - t_0^2$$

Δt is moveout, which is the difference in traveltime for a receiver at distance (x) from the source and the traveltime (t_0) for zero-offset distance, and supposing that $(t - t_0)$ is small (as it is for $(x << h)$ so that

NMO =

$$\Delta t = (t - t_0) \approx \frac{x^2}{2tV^2} \text{ ....(2)}$$

From equation (2) we note that (NMO) increasing as the square of the offset (x), inversely as the square of velocity (V), invesely as (t) increasing. If (Δt) is calculated for each sample on a trace and sample value placed at $(t - \Delta t)$, instead of hyperbola in Figure (6) we shall get a straight line through the vertex of the hyperbola, provided (V) is correctly chosen. A correction for (NMO) will depend on (travel time) on a single seismogram (trace) and is sometimes called the dynamic correction. This correction must be done for every time sample of each trace. If each seismogram is corrected for moveout using the value of (Δt) calculated from (t, x) and the correct velocity (V) chosen, any reflection event will algin at is zero-offset traveltime (t_0) instead of lying on the usual hyperbole. After the application of NMO correction avoids distortion of the hyperbolic shape of reflection prior to NMO. Stacking the events will produce a high quality reflection signals. Finally it should be emmphasized that, stacking the signals will produce a high quality reflection signals, as shown in figuer (1.C). For dipping layers the moveout relationship is more complex and Stacking is less effective of enhancing the reflections [9].

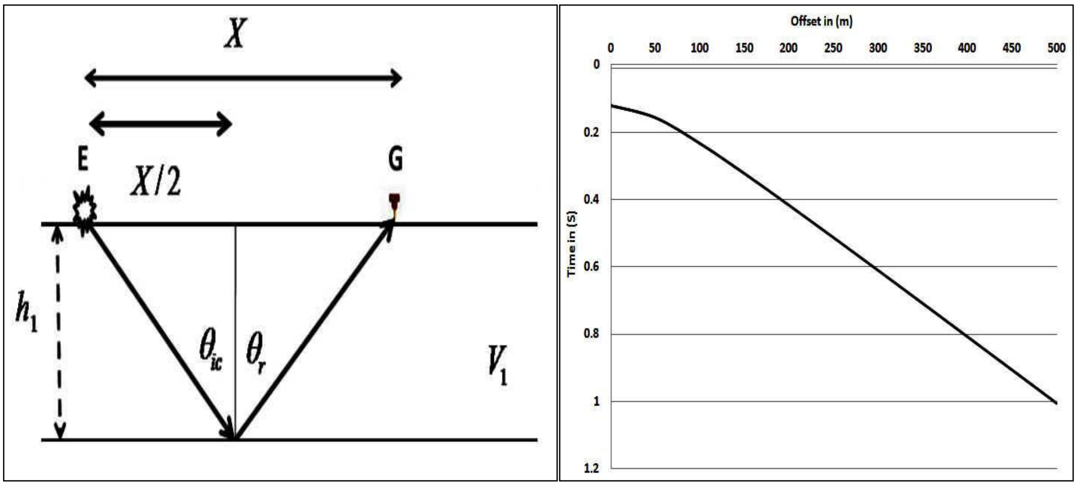


Fig (4). Geologecal model with one reflector (b) NMO curve (*with paramters, V =1400 m/s, depth 30 m, and Geophones increment 25m*)

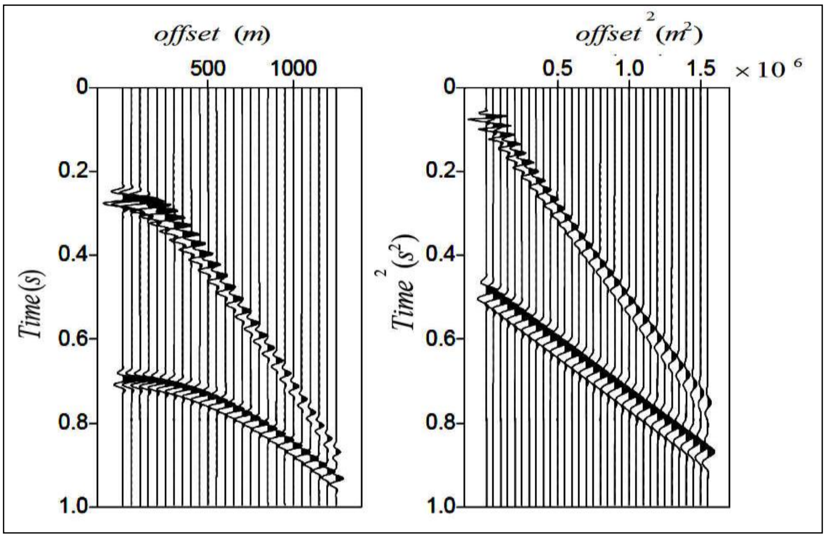


Fig (5). CMP gather with two reflections (a),and after the $\left[t^2 - x^2\right]$ axis stretching (b).

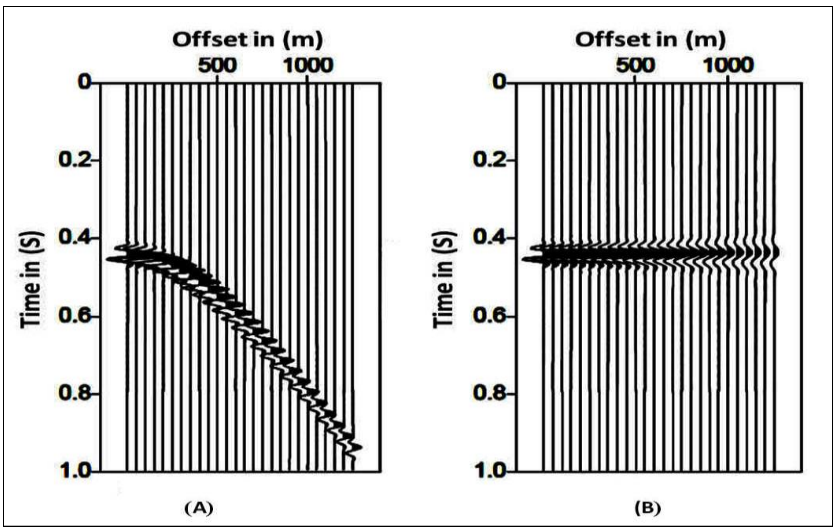
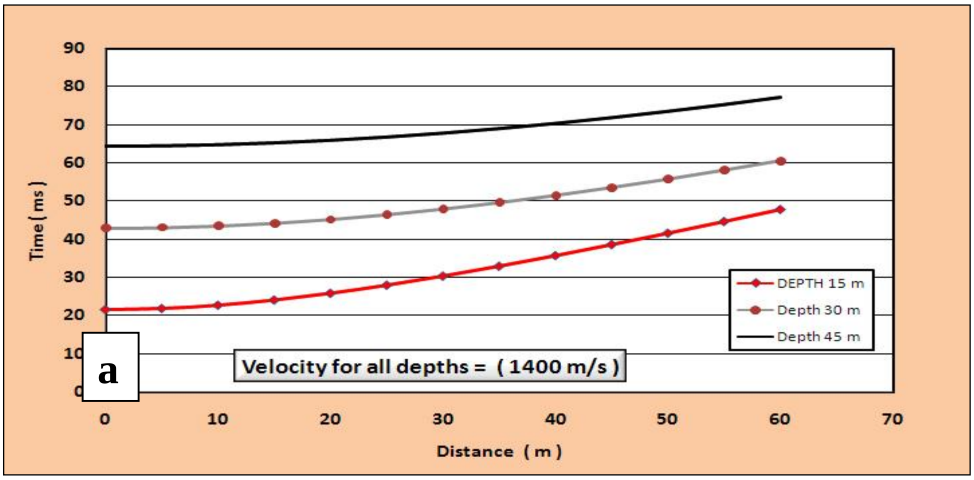


Fig (6). CMP gather with one reflection (A) before, And (B) after NMO eliminated (correction)

Methodology

Simulation with synthetic data

The conventional velocity analysis methods typically used for seismic data processing. It is assumed an ideal reflector, i.e. a homogenous reflector with flat interface and constant thickness. The medium is ideal, without energy loss. It is also considered non-dispersive[10]. The analysis of equation (1) determine to tell us about the subsurface regarding the depth and velocity in order to enhance the stacking for having the velocity model. It is very important to determine how these factors affect curve form. The basic parameters for establishing traveltime for a wave reflected from a single horizontal interface is straightforward. Referring to figure (4). Indicates that, the depth of the reflector interface selecting as varying (15- 30- and 45 m). It shows constant velocity of the medium is varying as well as (1400 – 3500 – and 6000 m/s) respectively. After building the model, the calculation of traveltime results corresponding to the above values. Figure (7a) illustrate the effect of depth difference. All curves calculated with (1400 m/s). it's clear from Figure (7a) the degree of curvature is greatest for shallower reflector with curvature decreasing with increasing depth. Increasing velocity also reduce the curvature of reflection traveltime curves for constant depth (30 m), this effect is illustrated in Figure (7b).



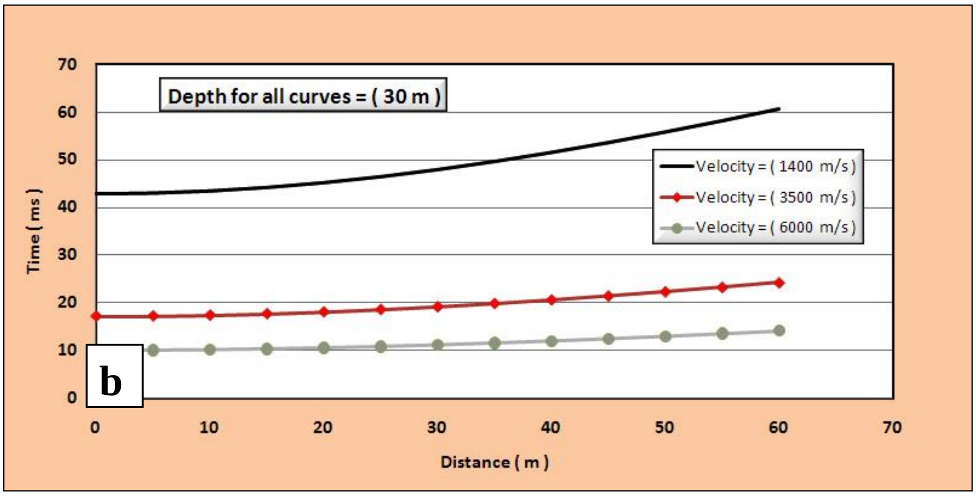


Fig (7) time-distance plots demonstrating the effect of depth and velocity on curvature of reflection traveltime (a) effect of depth using constant velocity. (b) effect of velocity with depth constant.

Calculation of (NMO) for three different combinations of velocity, and depth. Figure (7a) presents this information in graphical form. By subtracting (t_0) from reflection travel-times to get (NMO). Referring to figure (7a) it's clearly observed that the NMO decreasing with increasing depth to the reflecting surface, as well as with increasing velocity. On the other hand, it's increasing with increasing source-geophone distance (offset).

In particular, figure (8) plots NMO against source-geophone distance for three geological models. Normal moveout values is illustrated in figure (8).

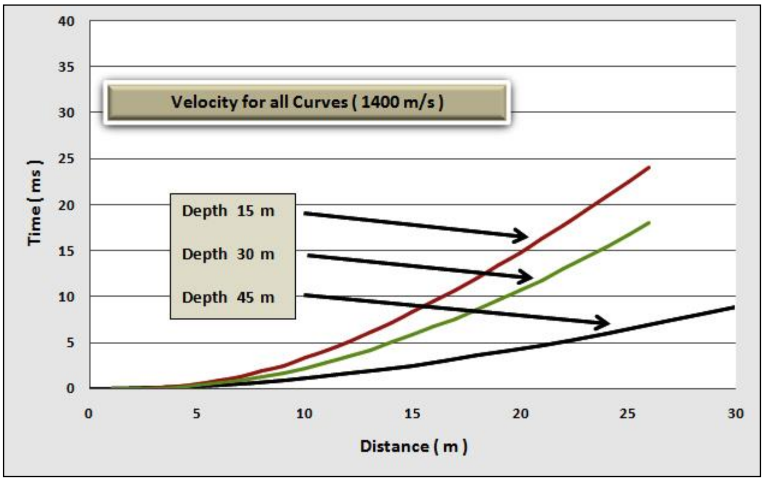


Fig (8) illustration of (NMO) curves for various interface depths at constant velocity.

Since, if the velocity is correct, this well results in flatting of the hyperbolas and the desired reflection will align perfectly. On the other hand, when the velocity is too low, the reflection is overcorrected; the reflection curves upwards. When the velocity is too high, the reflection is undercorrected; the reflection curves downwards. An example of these cases is illustrated in figure (9)

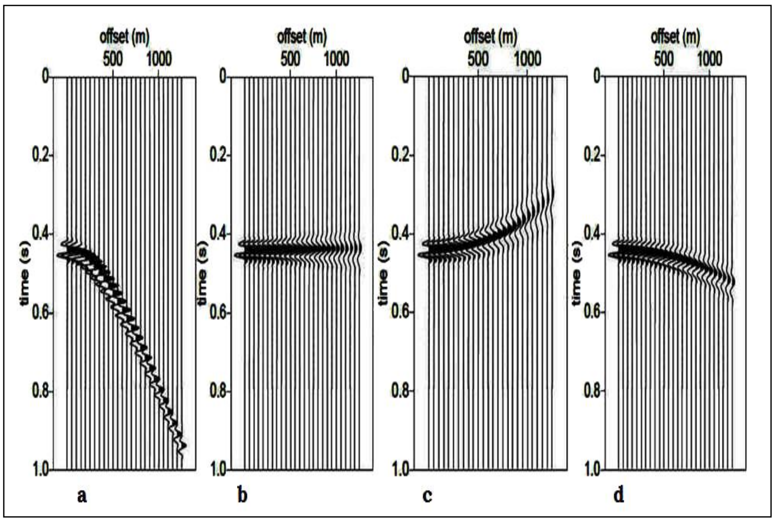


Fig (9). CMP gather with one reflection . (a) Reflection is not corrected; (b) proper velocity is chosen; (c) velocity is too low, and (d) is too high stacking velocity

Conclusion

- The purpose of seismic processing is to manipulate the acquired data into an image that can be used to infer the sub-surface structure and hydrocarbon accumulations.
- A characteristic of seismic data as obtained for the hydrocarbone exploration is that generally show a poor (S/N) ratio. Numerous techniques that can be used in seismic processing is to enhance the (S/N) ratio, and one of them is so called dynamic correction (NMO). It is the most important criterion for identifying reflections, as well as the principal method of determining velocity.
- stacking the seismic signals will produce a high quality reflection signals. If the proper velocity has been chosen for (NMO)
- The basic concept behind stacking the seismic data, is NMO corrected traces within a CDP which are summed together. This approach decreases the noise and enhances the seismic signal in the data.
- The objective is to determine stacking velocities (rms-velocities) which will result in the highest signal to noise ratio (S/N) of the final stacked seismic section used for a geological interpretations.

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