# Application of Velocity Analysis Picking for 2D Seismic Data Processing in West An-Najaf Are

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**Abstract**

In the current study, 2D seismic data in west An-Najaf (WN-36 line) were received after many steps of processing by Oil Exploration Company in 2018. Surface Consistent Amplitude Compensation (SCAC) was applied on the seismic data. The processing sequence in our study started by sorting data in a common mid-point (CMP) gather, in order to apply the velocity analysis using Interactive Velocity Analysis Application (INVA) with Omega system. Semblance of velocity was prepared to preform normal move-out (NMO) vs. Time. Accurate root mean square velocity ($V_{RMS}$) was selected, which was controlled by flatness of the primary events. The resultant seismic velocity section for the study area shows that the velocity analysis became smother and provided an accurate seismic section.

**Keywords:** Seismic data processing, West An-Najaf, Surface Consistent Amplitude Compensation (SCAC), velocity analysis picking, Seismic reflection method.

## تطبيق تحليل السرعة في معالجة البيانات الزلزالية ثنائية الأبعاد لمنطقة غرب النجف

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**الخلاصة**

في هذه الدراسة، استلمت البيانات الزلزالية ثنائية الابعاد لمنطقة غرب النجف (الخط36-WN) من شركة الاستكشافات التغطية عام 2018 حيث ان اجري عليها عدد من خطوات المعالجة. تم اجراء تعويض السعة (SCAC) كاحد عمليات المعالجة ثم استمرت سلسلة المعالجة للبيانات الزلزالية بخزن البيانات في تجميع النقطة الوسطية المشتركة (CMP-gather) لغرض تطبيق تحليل السرعي الاول ( Velocity Pass-1st Analysis) باستخدام تطبيق (Interactive Velocity Analysis INVA) من خلال منظومة الاوميكا (Omega). تم استخدام ورسم التمثيل السرعي (Semblance) حيث تم اختيار السرع الـ (RMS- Velocity) المناسبة والتي تسيطر على رتابة الاحداث الاولية لغرض الوصول الى التحليل السرعي المناسب ثم رسم مقطع للتحليل السرعي للخط الزلزلي لمنطقة الدراسة. بين مقطع التحليل السرعي الناتج ان توزيع السرع اصبح اكثر اتساقا وانتظاما بعد الامرار الاول للتحليل السرعي واعطى مقطعا زلزاليا اكثر دقة.

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**Introduction**

The seismic reflection method is one of the significant geophysical techniques in petroleum investigation. The hydrocarbon investigation history was started in the beginning of the last century using seismic reflection and other geophysical methods [1]. These seismic reflection explorations passed through many development stages from the middle of the last century up to the present time, including field surveys as well as data processing and interpretation with advanced software [2]. This method is the most widely used geophysical technique; it bears more direct and detailed photographs of the subsurface geological structures. Depths to interfaces are mapped very accurately. Certain difficulties were reported to arise when reflection is used for beds of complex faulting, folding and steep dip [3]. This information could be used to determine the geometric interpretation of internal stratigraphy in terms of environmental deposition paleogeography and analysis of sedimentary basin before the information is applied to the process [4]. Depths to reflecting interfaces can be determined from the times using velocity datum that can be obtained either from the reflected signals themselves or from surveys in wells. In recent decades, reflection data have also been used, usually based on velocity, to determine lithology and detect hydrocarbons, particularly gas. This is directly based on reflection amplitudes and other seismic indicators. Seismic data are usually associated with a large number of noise sources. One of the important parameters used in seismic data processing is velocity analysis. The accuracy of velocity picking in velocity analysis affects the quality of seismic data processing [5]. In this study, a velocity analysis module was applied on 2D seismic survey line in west An-Najaf area (ture-1) using Omega SPS version 2017 software. Type of spread for this line is symmetrical split, receiver station interval is 50m, source station interval is 50m, type of source is vibrators, length of spread is 90m, sampling interval is 2ms, and record length is 6s.The seismic processing was achieved in the Processing Department of Oil Exploration Company (OEC), Ministry of Oil, Iraq. The aim of this research is to study the effect of velocity analysis and normal moveout of reflected seismic events in CMP gather. We also aimed at increasing the seismic data quality in the stack section by choosing a better result of velocity picking analysis.
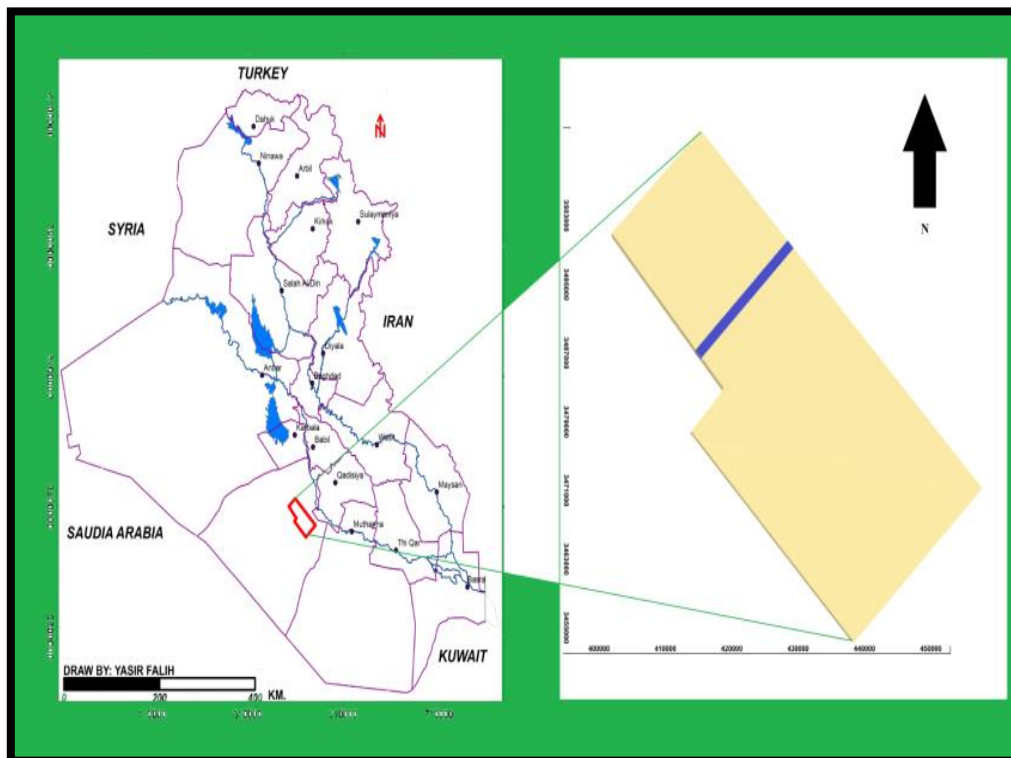


**Figure 1-** Location map of the study area

**Theoretical Background**

Velocity analysis is a set of processes that estimate speed values of seismic waves that produce an optimal stack. Velocity analysis can be performed on post-stack migration or pre-stack migration data

[6]. Common-midpoint knowledge is generally involved in determining the speed associated with the best-fit hyperbola [7]. However, even in the absence of noise and errors, knowledge on time-offset is not hyperbolic, except in the case of constant velocity. Also, the accuracy of stacking velocity is often somewhat dependent on the amount of data included in the analysis. The velocity of stacking is approximately the velocity of RMS, where all reflectors are horizontal and velocity varies only with distance. Velocity analysis is normally more than 3-10 CMP on average and may require selecting around 50 $(t - x)$ pairs [7].

There are different approaches to determine the velocity [8], including:

**A.**        $(t^2-x^2)$-Analysis.
**B.**        Constant Velocity Panels (CVP).
**C.**        Constant Velocity Stacks (CVS).
**D.**        Analysis of Velocity Spectra.

   Selected CMP gathers are used for all methods. Velocity spectrum analysis is typically the most commonly used method. The velocity spectrum is obtained when the stacking results for a velocity array are plotted side by side on a velocity plane versus two-way travel time in a panel for each velocity. This approach is widely used to calculate the velocity by interactive technology [9]. Using the semblance is the most common method that can be used to evaluate a velocity spectrum.

The semblance is a graph of velocity that is applied to preform Normal Move-Out (NMO) with time. It shows a measure of stack power for each velocity at each time, which is represented by different colors. The semblance calculation was an essential tool for seismic record velocity analysis. Conventional seismic velocity analysis scans different values of effective velocity of travel, measures the presence of flattened gathers, and produces velocity spectra [10].

**Data Processing, Result, and Discussion**

   Analysis was applied on 2D seismic reflection data achieved in west An-Najaf (WN-36 line) by OEC in 2017. After a processing step of surface consistent amplitude compensation (SCAC), the seismic data is split into a part that contains the primary noise and an unpredictable part that contains random noise. Random Noise Attenuation (RNA) was used to reduce random noise, increase continuity of events, and attenuate nonlinear noise. It cannot be used to suppress coherent noise, such as multiples, because its coherence implies predictability, making it appear as a signal. RNA is used in 2D stacked data and pre-stack gathers. It can be used to enhance coherent events relative to random noise using $(F - K)$ filtering technique that automatically selects the range of dips to enhance the signal based on the dips on the data. Figure-2 (A and B) shows the seismic CMP section before and after RNA filtering, while Figure-2( C) shows the CMP super gather to be used in velocity analysis in the current study.
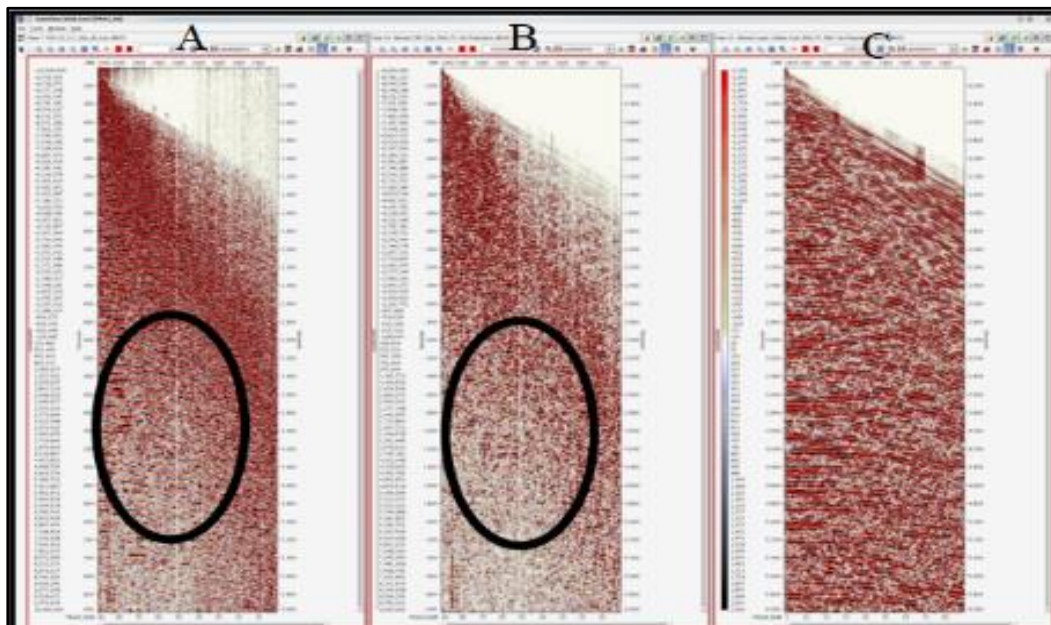


**Figure 2-** CMP preparation. (A) The CMP after SCAC, (B) The CMP after RNA filter, and (C) The super gather to be used in velocity analysis in the current study.
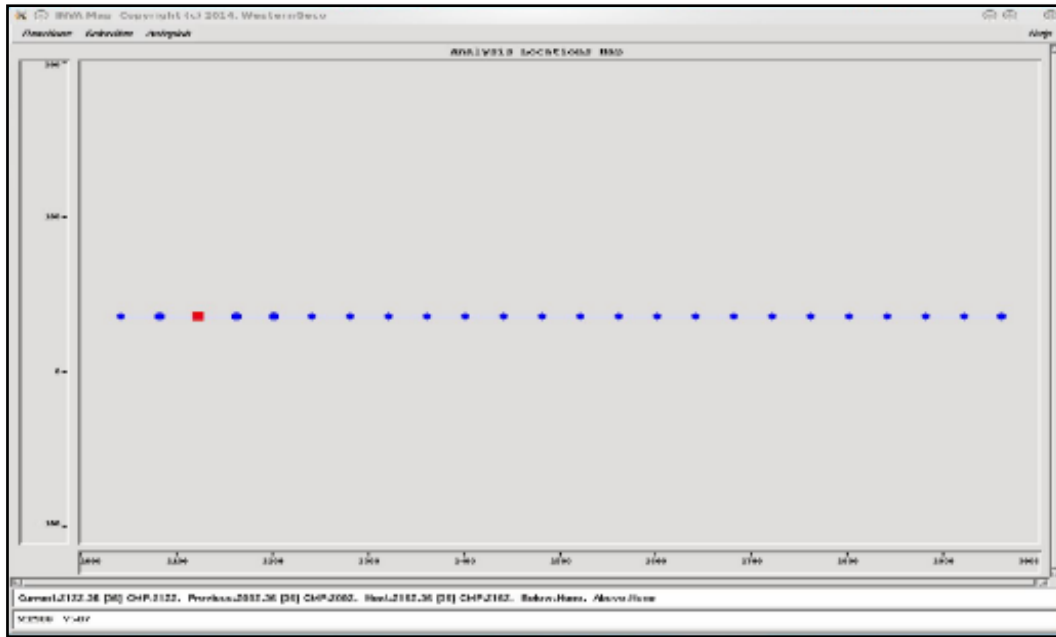
**Figure 3-** Velocity analysis location map of WN-36 seismic data.

Before the first pass of velocity picking, seismic data is prepared. The first pass of velocity analysis was performed in west An-Najaf using Interactive Velocity Analysis Application (INVA) with Omega system. Semblance is a graph of velocity applied to preform NMO vs. time, which shows a measure of stack power (flatness). Semblance is the most commonly used way to determine the velocity spectrum [11]. Velocity analysis function is taken from 2D line by applied for stacking. First pass velocity was picked every 40 CMP, with the spacing for CMP being 25m, which corresponds to 1km spacing. Figure-3 shows an analysis location map of the WN-36 line. Every point in the map contains a CMP gather to be selected and processed in semblance as control points on the seismic line.

When a CMP point (the red point in Figure-3) is selected, a semblance window will appear, then the velocity is processed manually (within the expected velocity range of area) until the primary events become flat or near flat and hence, the multiple will be recognized. Figure-4 shows semblance, NMO/CMP gather, Multi Velocity Function Stacks (MVFS), brute stack and velocity section, which explain steps of developing semblance in velocity analysis.
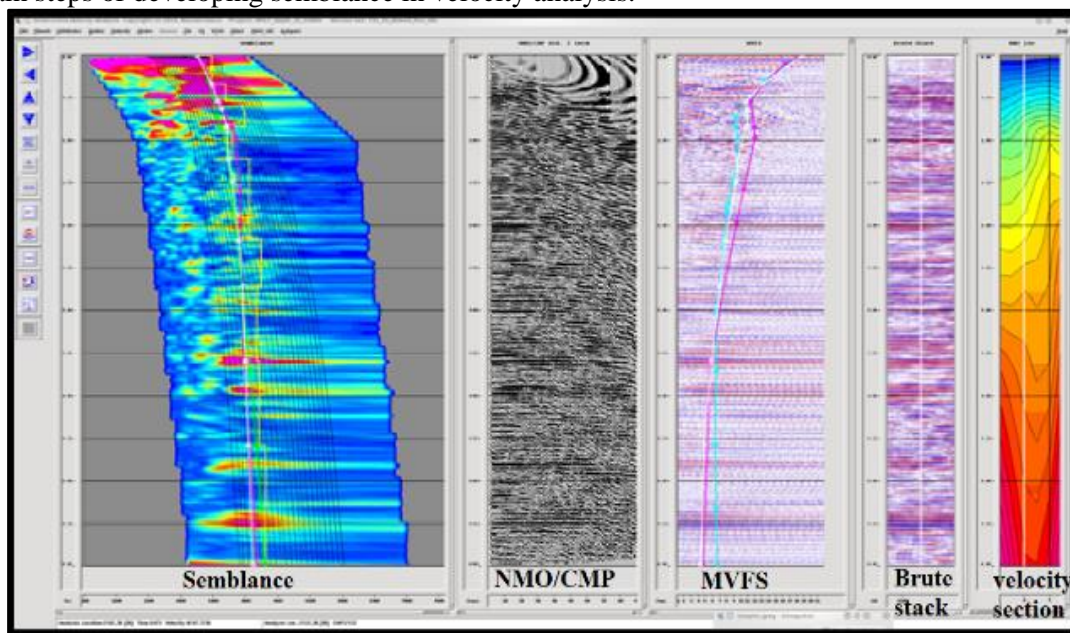


**Figure 4-** The Semblance, CMP gather, MVFS, Brute stack and NMO Iso velocity picking analysis.

Figure-5 shows a zoom in of the semblance section from (Figure-4). The yellow line represents the interval velocity, the green line is the RMS velocity for the CMP located before the in-process CMP point, while the pink line is the RMS velocity for the next point which is used for comparison and to give the processing more confidence.
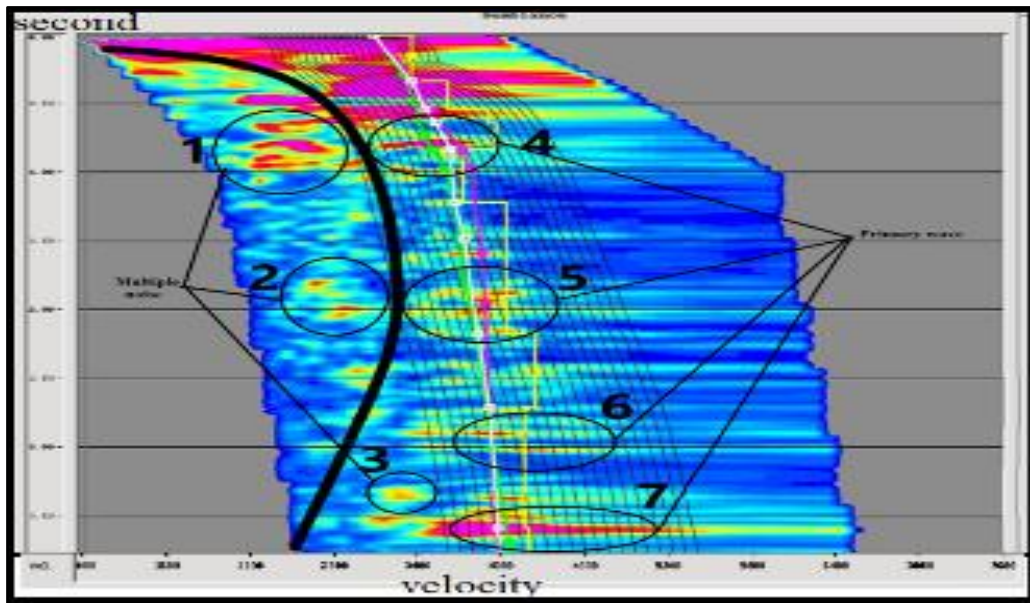


**Figure 5-** Example section of semblance zoomed from Figure-4.

Processing is achieved by adjusting the velocity of the primary events and the other line of velocity, which aids in selecting a suitable velocity for the point in-process. The final step is represented by the white line (RMS for the section) in this section. The processing and adjusting of the white line is controlled by flatness of the primary events (Figure-4, NMO/CMP section). The more flatness of events means more accuracy of RMS values. The multiples (circles 1,2 and 3) can be recognized from those of primary events (circles 4, 5, 6 and 7) (Figure-5).

The first-pass of velocity analysis is performed after the suitable RMS for each CMP is determined, so that the velocity section for the seismic line as a whole could be performed as shown in Figure-6. It seems clear that seismic velocity in the velocity section appears as smoother than that before the first pass of velocity analysis, as shown in Figure-6.
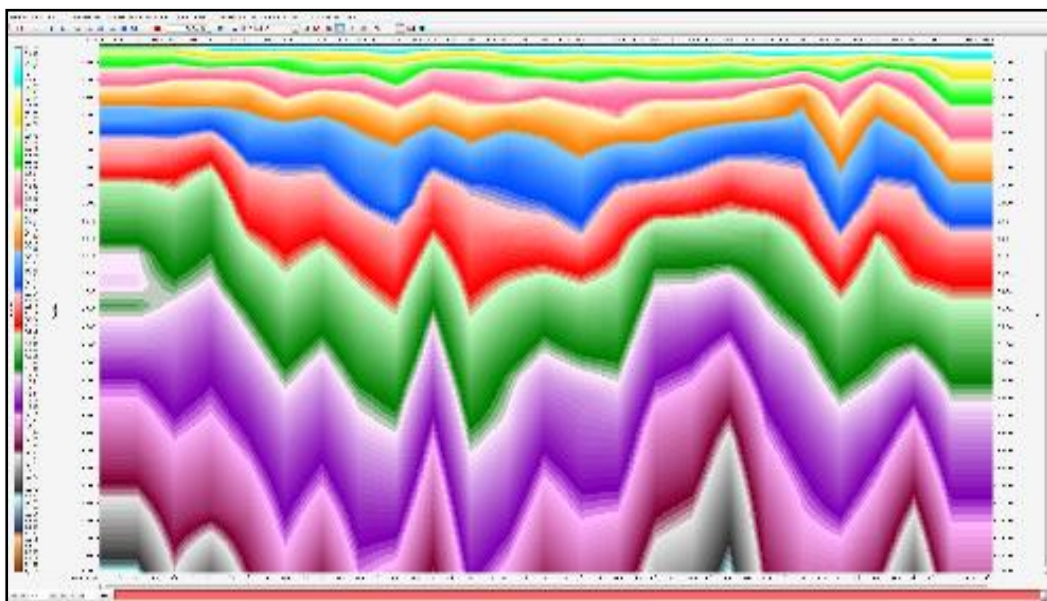


**Figure 6-** The velocity section after first-pass of velocity analysis.
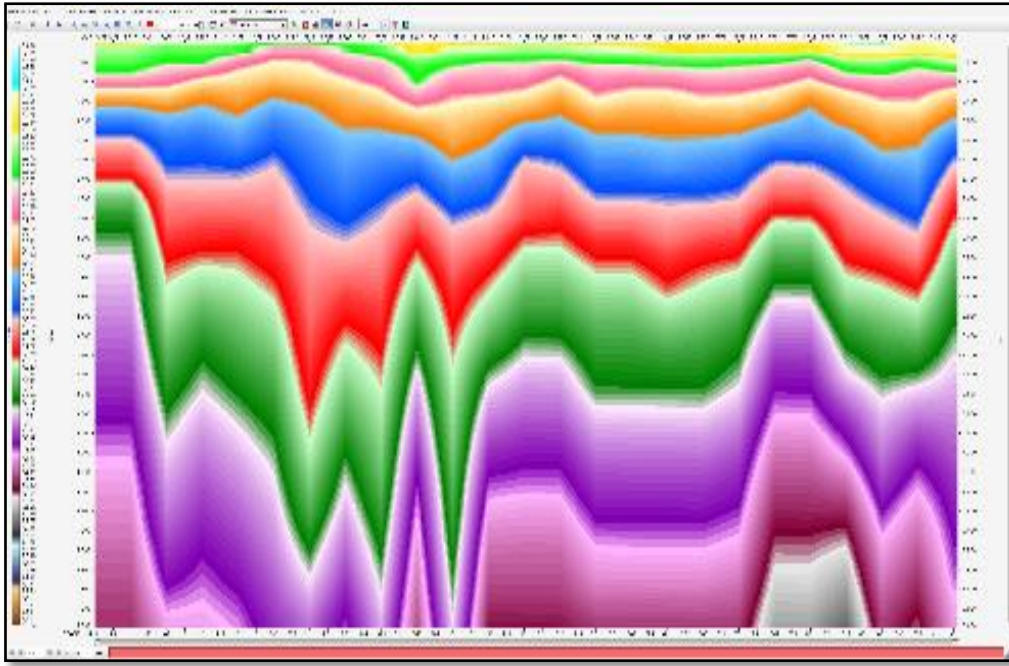
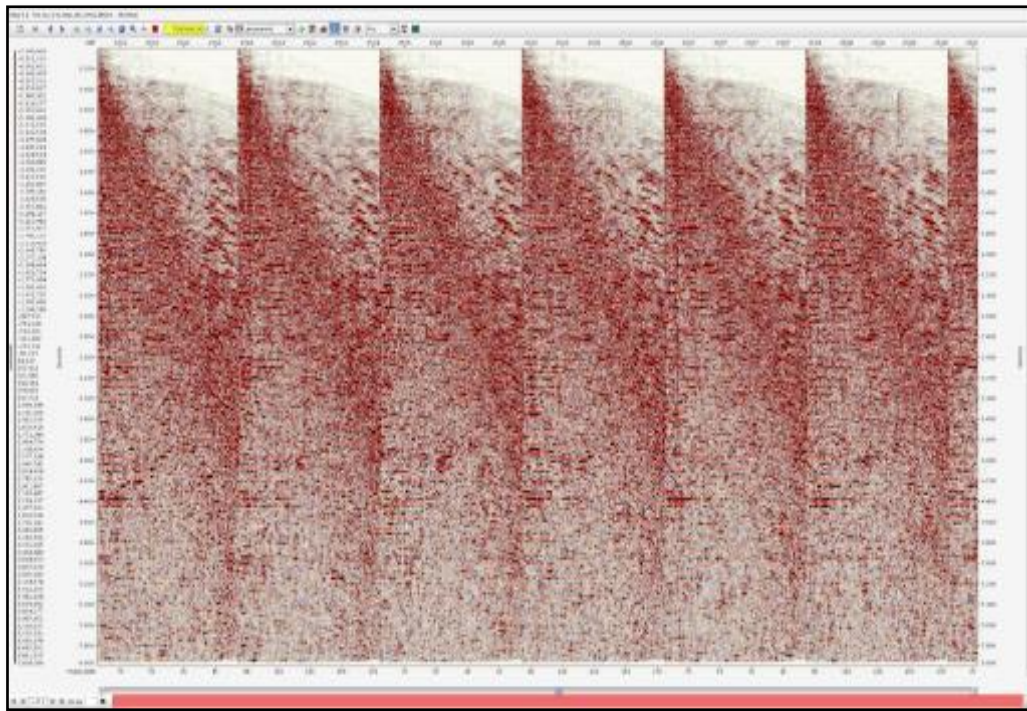**Figure 7-** The velocity section before velocity analysis.



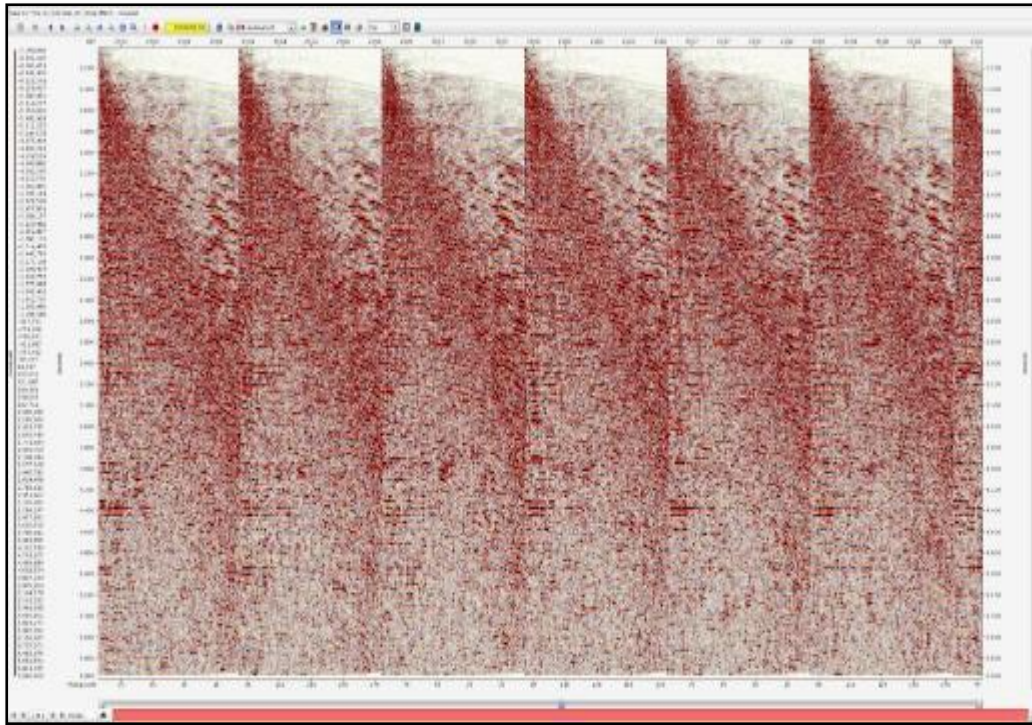**Figure 8-** CMP gather before first pass of velocity analysis.

**Figure 9-** CMP gather after first pass of velocity analysis.

The CMP result from the first pass of velocity picking analysis makes the primary wave flat or near flat, whereas the noise (multiples) is still parabola and easy to be recognized. Figure-8 shows the CMP before the first-pass picking of velocity analysis while Figure-9 shows the CMP after first-pass velocity analysis. To show the results of this process, i.e. the first-pass velocity analysis on CMP, an example is shown in Figure-10.
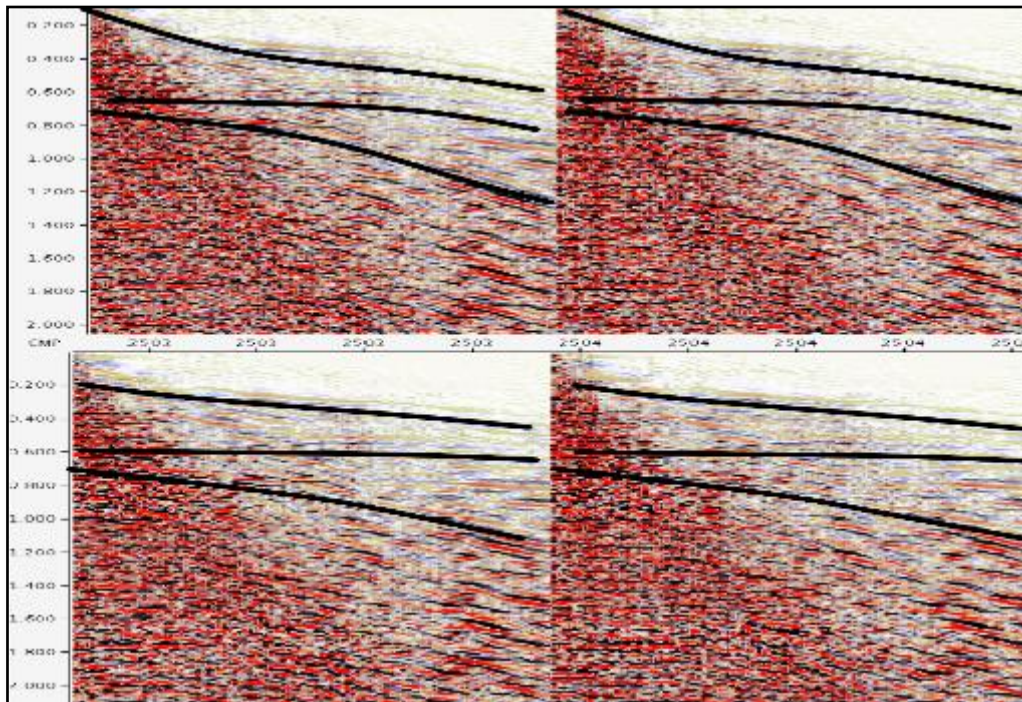


**Figure 10-** An example of CMP gather before and after first-pass velocity picking analysis.
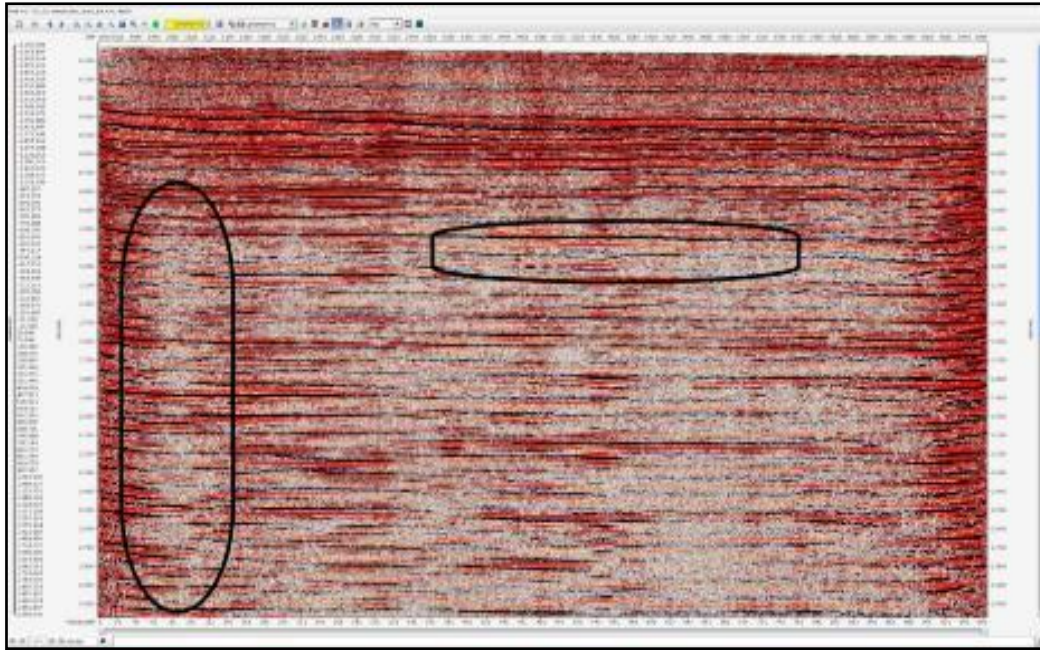
**Figure 11-** Stack section of seismic data before velocity picking analysis.

The process of CMP-stacking is the summation of the traces of a CMP gather. This is performed after the first-pass of velocity picking analysis. Each CMP-gather will, after stacking, give one stack trace, showing an enhanced reflection wavelet with (S/N) enhancement of the reflection events. The main advantage of the CMP stack is enhancing the seismic reflection signal [10, 11]. This is because reflection events are summed in phases, resulting in constructive interference, whereas the background noise, being of random nature, is destructively interfering [8]. Figure-11 shows the stack section before the first-pass velocity picking analysis, while the Figure-12 shows the stack section after that analysis. Figure-13 is an example of a zoomed in section of stack after and before first-pass velocity analysis. We can recognize the improvement due to enhancement of the velocity, which can further explain the event change by noise attenuation after CMP stacking.
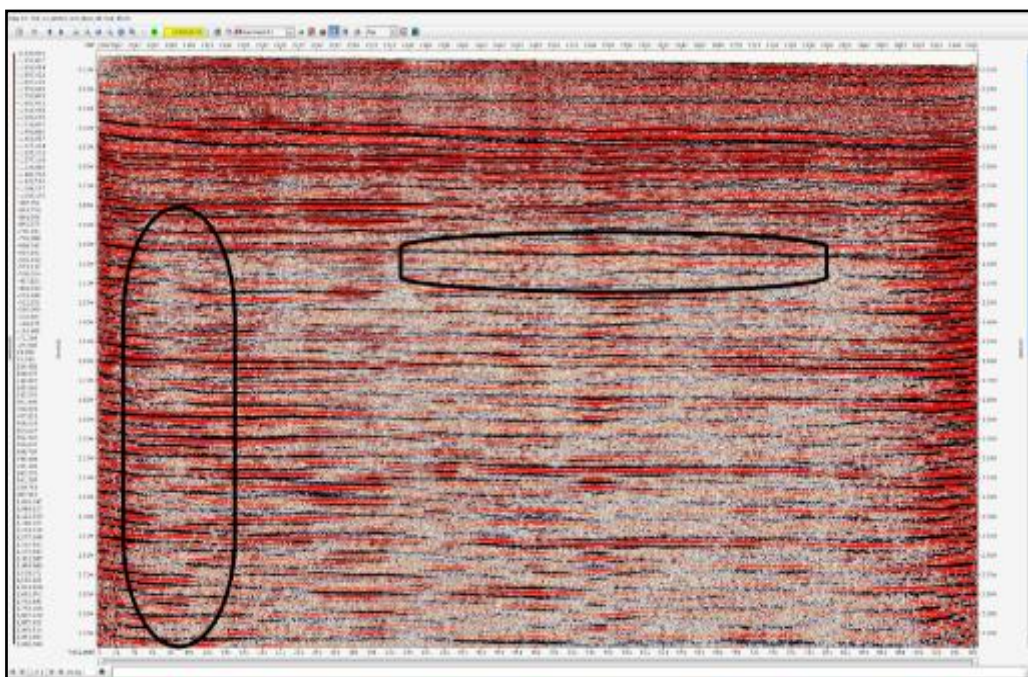


**Figure 12-** Stack section of seismic data after velocity picking analysis.
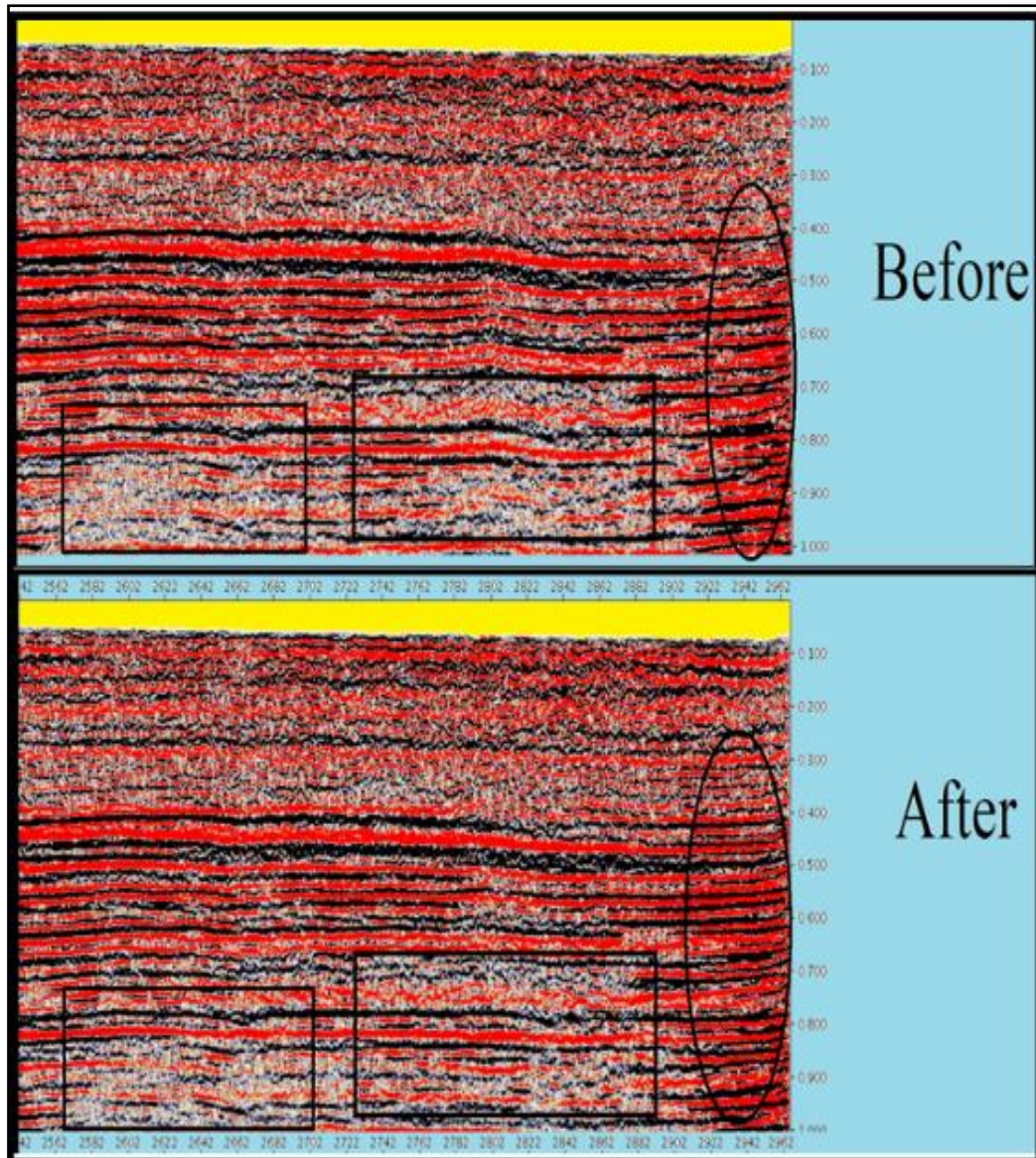
**Figure 13-** An example of a stack section (zoomed in from Figures- 11 and 12) after and before first-pass velocity picking analysis.

**Conclusions**

Random Noise Attenuation was applied on SCAC 2D seismic data after sorting them in CMP gather. RNA application makes the events more continuous by attenuating nonlinear noise. Interactive Velocity Analysis application in Omega system was performed on seismic data of West An-Najaf (line WN36) in the current study. Semblance was prepared to determine the velocity spectrum. Processing of semblance makes primary events flat or near flat in the NMO corrected CMP gather. In semblance application, accurate RMS of primary events is selected, which is controlled by flatness of the primary events. Seismic velocity section for the study area was conducted by applying first-pass velocity analysis on data for the 2D seismic line. This section shows that velocity analysis becomes smoother but still affected by multiples, although the primary events become flatter in CMP gather and in CMP stack section. This study confirms that selecting the accurate velocity in velocity analysis is of an important role in the enhancement of the stack section.

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