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Research Article

Updating The 2D Seismic Data by Pre Stack Depth Migration of Khashim Al-Ahmer Gas Field Northeastern Of Iraq

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Abstract

Khashim Al-Ahmer Gas Field is located at North-Eastern Iraq, particularly in Diyala governorate. The final seismic data for this gas field is carried out through three main phases: acquisition operations, processing, and interpretations. This research is concerned with the second phase of seismic work, which is the seismic data processing phase, the seismic data processing phase also consists of three stages, and each stage includes a series of interrelated steps which are: noise attenuation stage, final stack stage, and the migration stage. The migration stage is an advanced step of seismic data processing, the purpose behind its application is to provide a more accurate image of the subsurface and close to the geological reality. The seismic migration has several types that are used according to the nature of the geological complexity. The type of seismic migration that was used in this research is the Pre-Stack Depth Migration (PSDM). This type of technique is used if the field to solve subsurface geological complexity, and the seismic velocity behavior is complex as well, this is actually present in the Khashim Al-Ahmer gas field, as it contains layers of evaporites within the L. Fars Formation it is subjected to a process of folding and thrusting. The Jerebi Fn. Which lays below considered as a major gas reservoir. These factors lead to a high attenuation of seismic waves energy and produces high uncertainty in interpreting variations of geophysical parameters, and the best solution was to remove this uncertainty by applying the (PSDM) technique. Where it is possible to recover the seismic signal strength also, to avoid the effect of high geological deformation resulted by folding, thrusting, layers of evaporites and the effect of gas reserve. This makes the interpretation process extremely easy for the interpreters.

Keywords

Pre-conditioning processing, Pre-Stack Depth Migration (PSDM), RMS velocity, Interval velocity, Initial model, Blocky (layered) model.

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Introduction

Kirchhoff summation method based on the integral solution of the scalar wave equation, which is one of the most commonly nowadays applied algorithms industrially and academically, (Schneider,1978). Strong lateral velocity variations associated with complex overburden structures requires earth imaging with depth. Examples of complex overburden include diapiric structures formed by salt tectonics, imbricate structures formed by over thrust tectonics and irregular topography, (Yilmaz,1987). Migration is the process that repositions reflected energy from its common midpoint position to its true subsurface location, (Dobrin & Savit, 1988). Migration is a seismic data processing technique to map seismic events onto their appropriate positions, (Sheriff & Geldart,1995). There are mainly two approaches of application to perform this technique: Time migration and depth migration, both of which can be done either after or before stacking, (Jones, et al, 2008). Building a velocity model suitable for the depth migration can significantly improve the quality of seismic data (both accuracy and continuity) also, to identify appropriate spatial-structural locations. For these reasons, special attention is required to establish an accurate initial velocity model in the time domain, as a starting point for building an updated and reliable depth velocity field for depth migration, (Grigorova, 2016). Migration solves (Bow tie) effects, converting them into successive synclines and anticlines, bow ties are commonly observed in areas of complex topography and are resolved by migration. Migration terminates diffractions, this would increase the focusing of seismic energy to their apex points, and fault planes become much clearer, (Dondurur, 2018). & (Obaid, & Al-Rahim, 2019). The Common Depth Point (CDP) and Common Mid-Point (CMP) must be avoided, especially the term (CDP), because there is no common point at the dipping reflectors. On the other hand, (CMP)always exist because they are defined by the geometric midpoint between sources and receivers, (Treky, & Al-Rahim, 2018).

Location of the Study Area and Data Source

Khashim Al-Ahmer Gas Field is located at the north-eastern part of Iraq within Diyala Governorate, and approximately (70 km.) northeast centre of Baquba city as shown in (Fig.1). The area has two wells (KA1, KA2). Only (KA2) has log data because KA1 was drilled in the years (1927-1928) and reached the transitional beds of L. Fars Fn. and was abandoned due to gas blow up, and perhaps the only information that can be used is to confirm the presence of gas in the field, (Iraqi North Oil Company, 1980). The second one is well (KA2) which was drilled in 1980, and penetrated Jaddala Fn. (Paleocene) with a total depth of (1705m), The presence of gas has been proven in the transitional layers, which are the last layers of the L. Fars Fn., and in the main reservoir below these layers in the Jerebi Fn., (Iraqi North Oil Company, 1980). The seismic data used in the processing are of a two-dimensional (2D), namely PULKHANA_INJANA_KHASHM_ALAHMAR or (PIK), (Fig. 2). Two surveys for the (PIK) project were carried out by the Fourth Iraqi Seismic Crew, (Fig. 2). Initial reconnaissance was surveyed in period (1976) to (1978) and the 4th seismic crew completed (872 km.) length with (34) seismic lines, divided into (18) dip seismic lines and (16) strike seismic lines, (Fig. 2). Detailed seismic survey of extended period from (1981) to (1982), and the 4th seismic crew completed (454 km.) length of the project, with (25) seismic lines, divided into (19) dip seismic line and (6) strike seismic lines, (Fig. 2).Thus, the total sum of both the reconnaissance and detailed surveys with all their time stages is (59) seismic lines, and the total length of the outlet was (1326 km.), (Fig. 2), (Kammuna, 1990). The (PIK118) is the two-dimension seismic line of (PIK) survey that has been chosen to apply the depth migration technique. It is located on the axis of the structures of (Khashim Al-Ahmer Anticline), (Fig. 2).

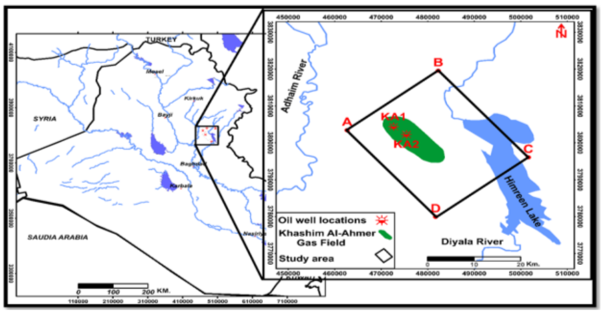

Figure (1) Location maps of the study area

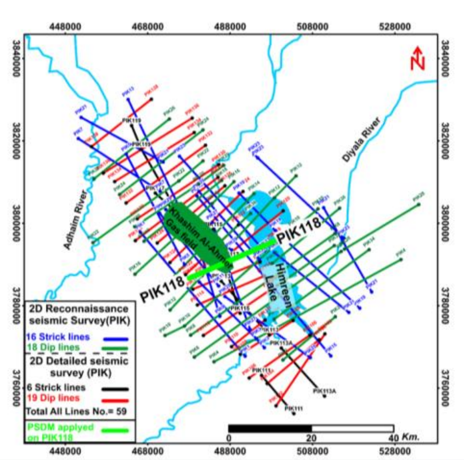

Figure (2) Illustrates base map all (PIK) surveys and showing especially the seismic line (PIK118) in a light green color which technique pre stack depth migration (PSDM) has been applied on it. (Kammuna, 1990).

Methodology

The processing of seismic data in depth domain requires various steps to reach the final performance indicating the genesis of the subsurface seismic section, (Fig. 3) shows those steps.

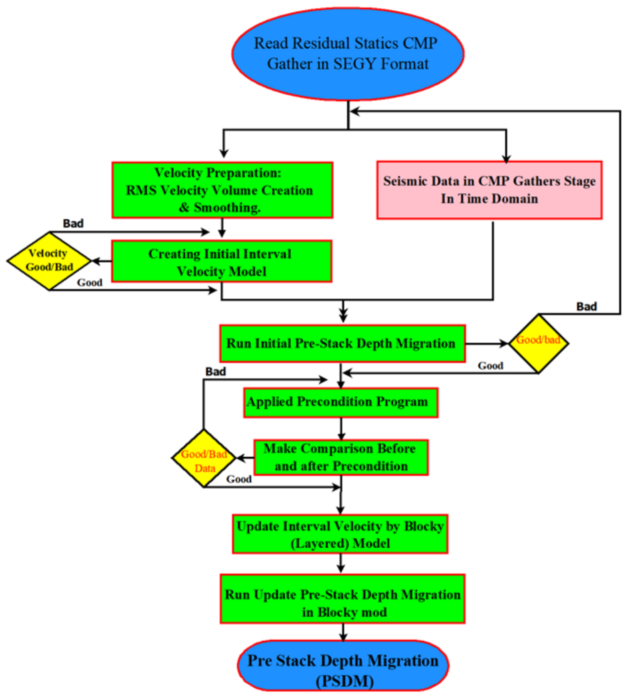

Fig. 3: A flow chart summarizes the main steps of Pre-Stack Depth Migration (PSDM) process.

The (PSDM) is applied on the oil fields that are characterized by complex velocity arrivals and complex subsurface geology. These complex geological features are present in the Khashim Al-Ahmer gas field, where the field is exposed to a system of thrust faults in the level of the L. Fars Fn., in depth range (729-1838 m and contains layers of evaporates in addition to the topographical complexity of the region because the field is located near the folded zone. These geological reasons cause the high dispersion of seismic energy and caused the bad quality in seismic data. Therefore, in such areas (PSDM) technique is useful to be applied as the following:

Input Seismic Data

The seismic data entered to depth migration processing operations are as a (CMP) signals which migrated in time domain as a shown in (Fig. 4), and this seismic data must be free from any noise as possible which will be qualified to be entered into the algorithms of the Depth Migration.

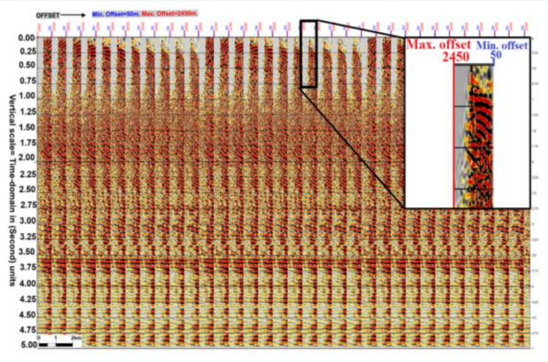

Fig. 4: Common mid points (CMP) migrated gather in time domain with applied all noise removal programs to raise the (S/N) ratio.

Velocity Preparation: RMS and Interval Velocity Volume and Creation & Smoothing.

This procedure describes how to create the depth Interval velocity from the V_{rms} velocity**.** After creating the **R**oot **M**ean **S**quare (RMS velocity) model, which represents the processing velocity, smoothing process is applied, as it shown in (Fig. 5). By applying Dix Equation Vrms get transformed into interval velocity in the time domain, then get converted to depth domain in order to deduce a pseudo-3D grid as shown in (Fig. 6). Also, the difference between the (**A**uxiliary **D**atum **P**lane) (ADP) and the regional elevation is computed, form this surface Datum the migration operation started in work as it represents the plane which includes the source and receivers, (Fig. 6).

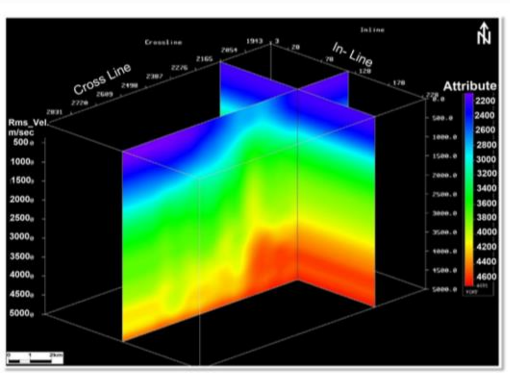

Fig. 5: Illustrated the Pseudo 3D RMS velocity Cube

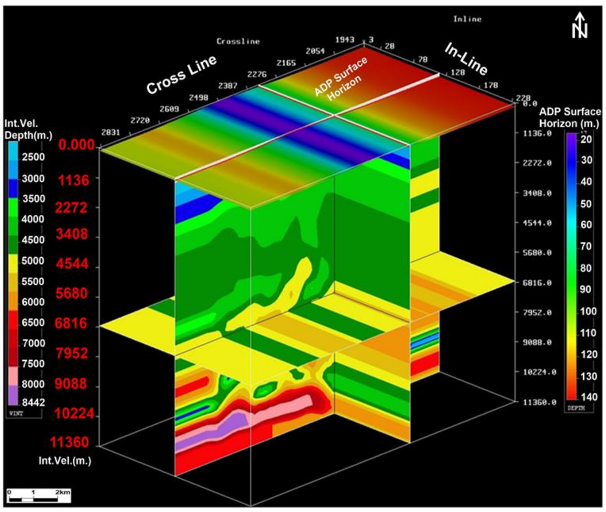

Fig. 6: Illustrated the dual-scale 3D cube model Pseudo 3D cube with inline and cross line interval velocity in depth initial model with ADP Surface and slicing interval velocity section.

Run Initial Pre-Stack Depth Migration

After obtaining the initial interval velocity in depth domain and input the filtered CMP gathers now it is possible to run the first Initial Depth Migration (IDM) on it. the first Initial Depth Migration on the CMP gathers. The importance of applying the process of Migration to the seismic data, which during the CMP gathers stage, is that the process of migrating seismic traces is applied trace by trace, (Fig. 7), represents the (IDM) Gathers. The (IDM) resulted data were stacked to produce the first initial depth migration section which named in this case Pre-Stack Depth Migration (PSDM) as shown in (Fig. 8), which are considered as preliminary results through which decisions are made to follow the next complex processes if this result is good, or to return to the first step if this result is bad. The common criteria in deciding or to insure if the results are good or bad in this stage of processing technique are the seismic section in-depth domain which is named Pre-Stack depth migration (PSDM), where the seismic depth section looks good quality in this case the processing operations continuing to next step, but in case the result is bad, it is returned to the previous step, which is the stage of building the interval velocity model, as the basis of the depth migration work is the interval velocity model that controls the validity and clarity of the seismic data in the depth domain.

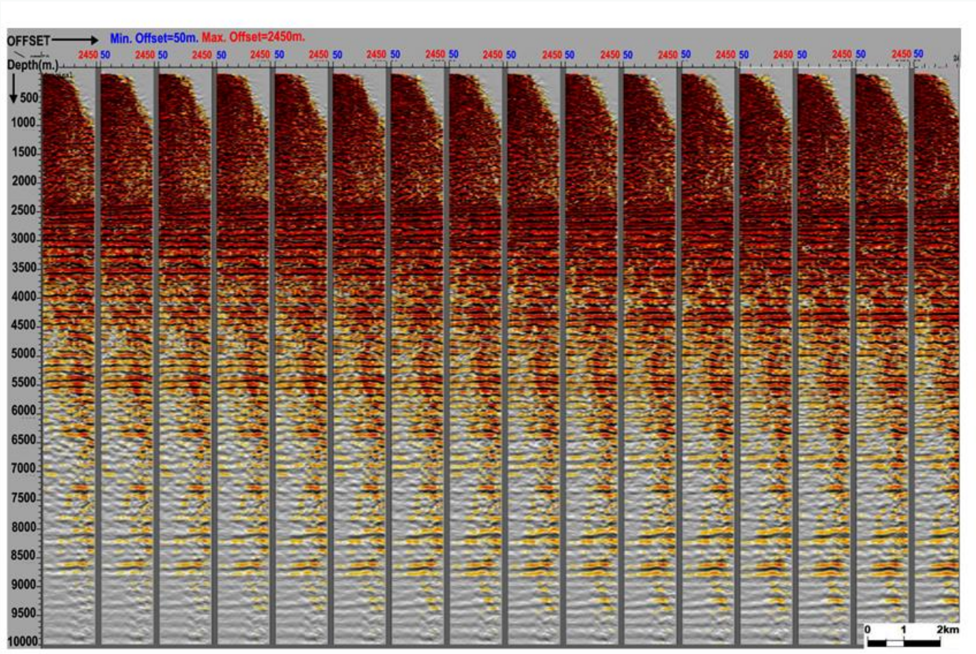

Fig. 7: Showing the application of (IDM) technique on (CMP) gathers.

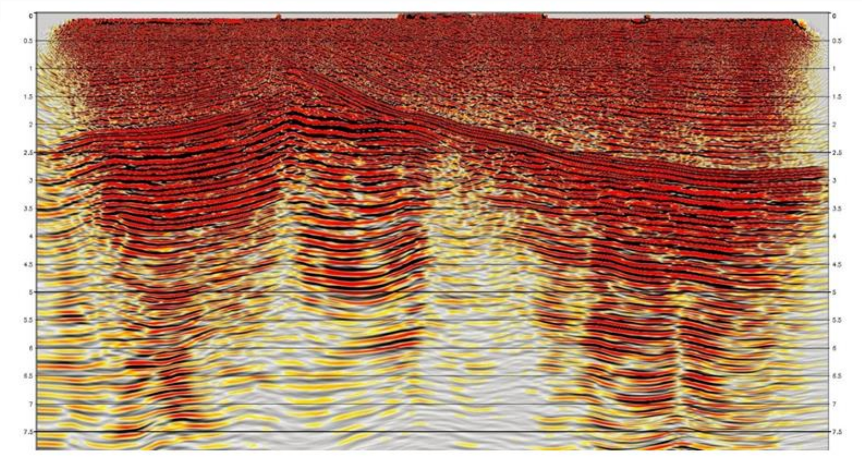

Fig. 8: Illustrates the pre-stacking (IDM) without Preconditioning.

Preconditioning on CMP Gathers

Preconditioning is especially useful as it improves the seismic gather and brings it closer to the geological reality in the subsurface, (CGG University, 2011). In this stage of the depth migration processing, updated velocity calculations are carried out through the preconditioning processes, which include several processes, the software works on Demultiple reflectors effect removal, and another program works on **S**urface **C**onsistent **Fil**tering (SCFIL), which performs the process of Smoothing structural image to remove the structure artifact. By observing the (Fig. 9) clearly, it was found that the extent of the improvement within the data after applying these (Preconditioning Programs), and it can be said that the improvement has included the general seismic data as it shown in (Fig. 9). These CMP Gathers are stacked for the purpose of displaying the data, and they are in the form of a migrated seismic section in depth domain as a kind of qualitative control over them. The satisfactory results of this process have been noticed. Results before and after preconditioning application are shown in (Fig. 10). Pre stack depth migration seismic data which preconditioning jobs applied on it. Thus, had finished the stage of the preconditioning on seismic data, (Fig. 10).

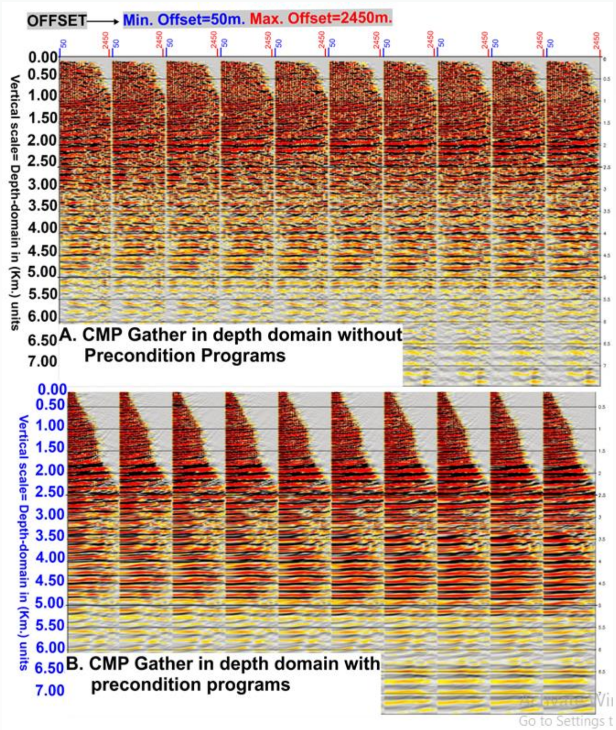

Fig. 9: Illustrates seismic data in CMP Gathers in initial depth domain shows the effect of preconditioning application. Whereas section (A) represents the seismic gather without Precondition, while in the section (B) after preconditioning application.

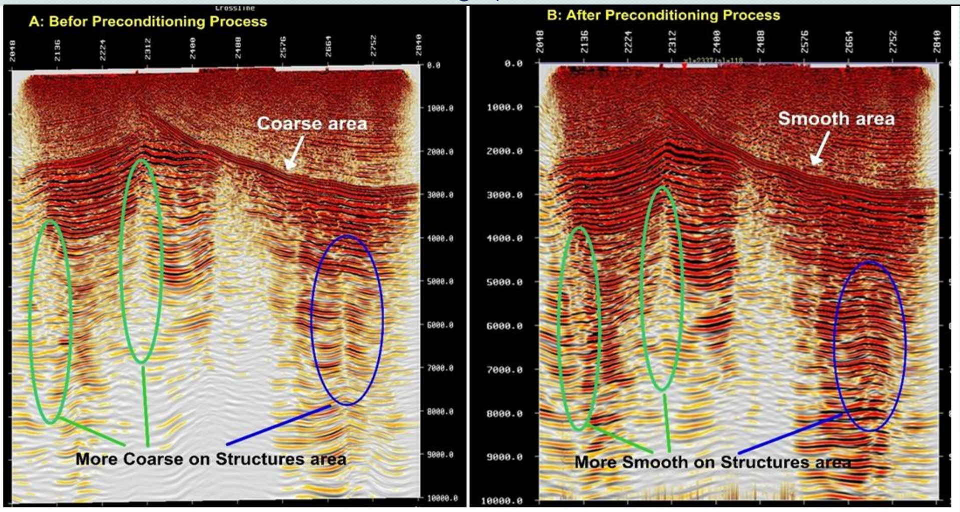

Fig. 10: Illustrates section (A) which represents the data before applying the preconditioning process applying the preconditioning process with section (B) which represents the improved data after applying the preconditioning process, particularly the pointed features inside both sections and one can notice the increased smoothness effect which appear in section B as compared to section (A).

Updating Interval Velocity by Blocky (Layer) Model

Pre-Stack Depth Migration algorithms include two important stages: the (Initial) stage or (Grid) stage, and the (Blocky) stage model. Thus, to convert data from the initial mode to the blocky model or layer model, in fact, this process includes several steps to achieve. Horizons must be picked in time domain, where in the current project five of them were picked to represent the formations: L. Fars, Jerebi, Dhiban, Jaddala and shiranish, (Fig. 11), after which were treated as surface to be as pseudo 3D then, these horizons converted from time domain to the depth domain, (Fig. 11).

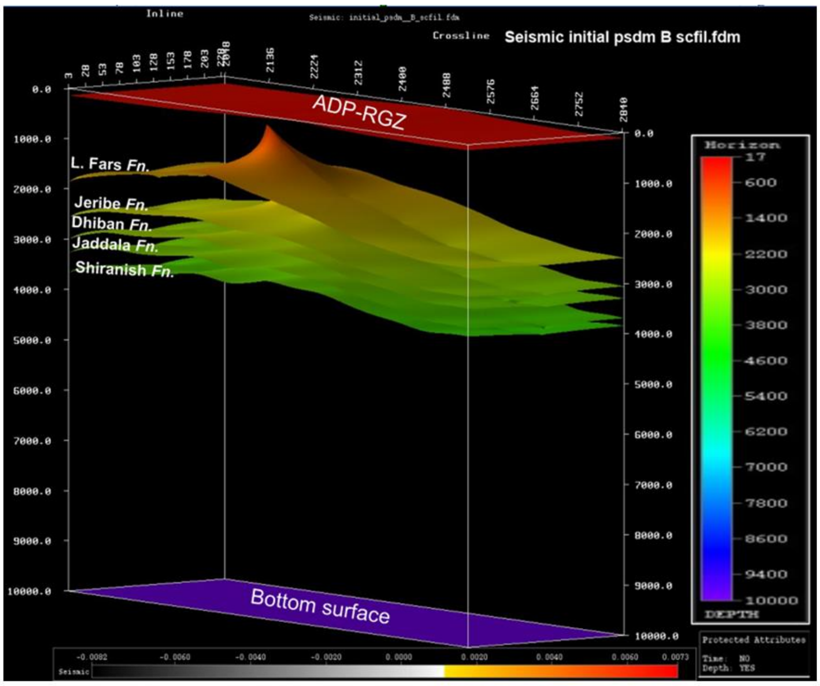

Fig. 11: An illustration showing the five horizons as surfaces which are: L. Fars, Jerebi, Dhiban, Jaddala and shiranish in 3D viewing.

Interval velocity will be run according to these five layers, this interval velocity in this case named Blocky interval velocity and all the seismic data after this stage named blocky or layered. The Blocky Interval Velocity model is shown in (Fig. 12), whereas based on that it will run the final seismic data. The run number of Blocky mod may be increased depending on the number of layers which required to make models for, and here they called (masks) And they were applied on depth migration data five times to compose five masks.

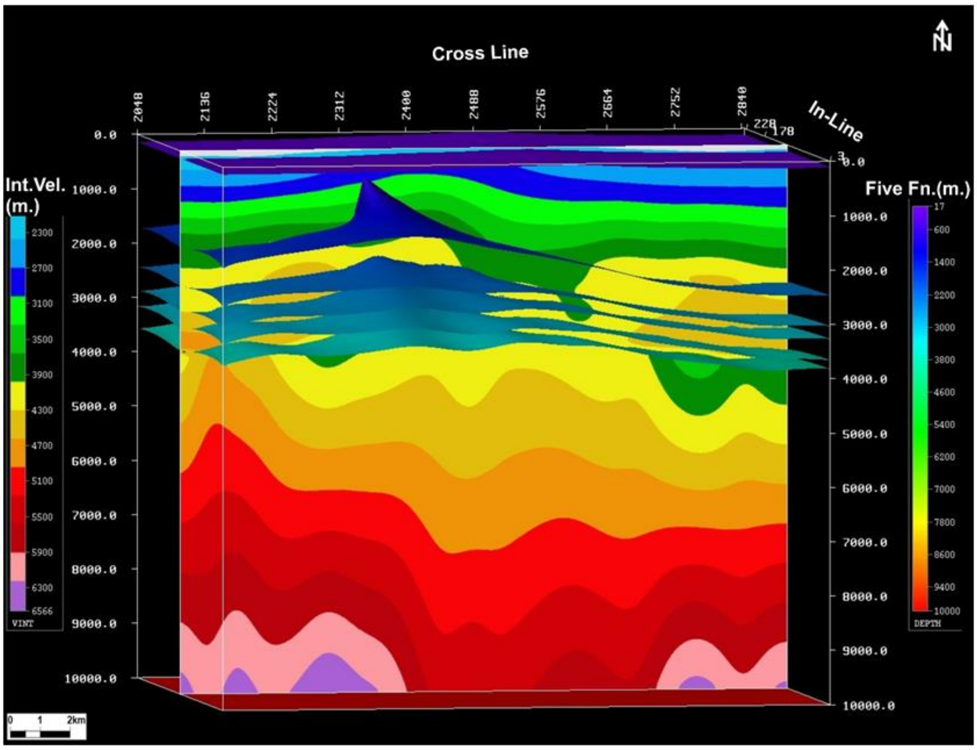

Fig. 12: An Illustration showing the interval velocity blocky (Layered) Model with the horizons layering.

Running the updated (PSDM) in blocky model.

The mechanism of depth migration depends on the interval velocity model, where corrects the location of the common mid points (CMP) and puts it in its correct place depending on the interval velocity, and when the interval velocity is realistic, the depth migration technique is more realistic.

In this important step, the process of updating (PSDM) is executed to apply a new run to the data on which all the preconditioning operations were done, then we run a stack operation on the corrected seismic gather, and then were compared the preconditioning data with the data of the blocky (Layered) model. After running the (Update Blocky model process), then (stack processing) run to enhance the results quality.

A comparison between Initial and the Blocky (Layered) models after applying the depth migration operation processing

Finally, the outputs from the applied of the initial processing is shown in (Fig. 13A) which illustrates the pre stack depth migration which resulted by the initial operation. It can be easily seen that an initial model was not able to handle the area of the structure indicated by the light green arrows, it was also found that an initial model was not able to treat the areas inside the oval shapes in light green colors in (Fig. 13A). But when velocity updated and applied on interval velocity Blocky (Layered) model which which works to divide seismic data into layers according to the targeted formation to create surface horizons and turning them to masks which presented in the block velocity model to show each formation layer. The results of updated blocky interval velocity model are shown in (Fig. 13B), whereas found the features which are indicated by the blue arrows showed an obvious improvement in defining structural features with a perfect resolution in perfect form, and the areas inside the oval blue-coloured bordered shapes handled in A perfect resolution and displayed subsurface structures as close as to its natural shape, (Fig. 13B).

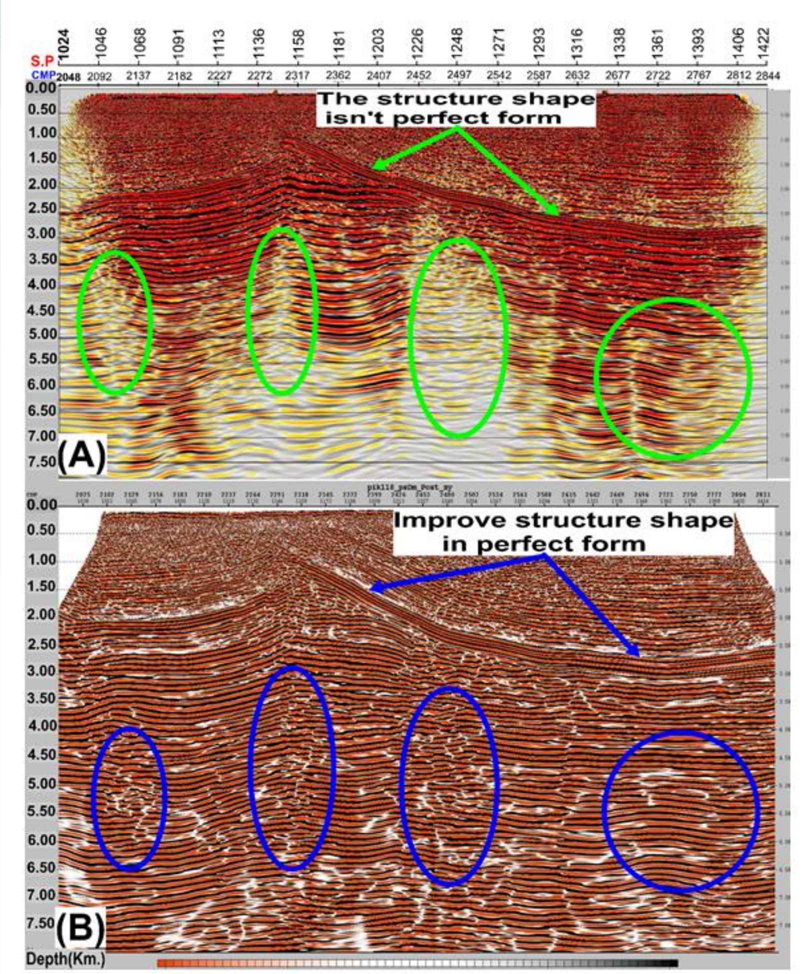

Fig. 13: Illustrates two sections of two operational stages where (A) shows the results of Initial Pre-Stack Depth Migration, and (B) show Pre-Stack Depth Migration (PSDM) Blocky (Layered) model.

Conclusion

The Pre-Stack Depth Migration technique is especially useful in imaging the subsurface structural geology; the results of the present study are shown:

- In a complex geology and velocity oil field (such as our case study), Pre-Stack Depth Migration PSDM technique must be applied to perform all seismic event in perfect form.
- The PSDM technique will be helped the geophysicist interpreter to perform all features which are in subsurface geology.
- The PSDM technique it is so complex process and so expensive in cost and it has a lot of time in run, and it need high speed CPU, because this technique deals with seismic data trace by trace, and it solves any complexity in subsurface and any deformation in geology.
- An improvement can be observed in all part of Khashim Al-Ahmer gas field data after using the PSDM, where in the shallow parts; all continuity of reflectors were observed and handled very well bowtie phenomena and changed it to syncline.
- The seismic operations in all seismic phase dependent on seismic velocity in general, and the PSDM technique in particular as all steps of this technique depend on how the velocity model is perfect.

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