Processing of 3D Seismic Data for Obtaining Accurate Image of Oil Trap

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ABSTRACT

Processing of seismic data is an indispensable step in exploration seismology. The purpose of seismic processing is to manipulate acquired data into an image or set of images of the subsurface geology. Processing consists of applying a sequence of routines on a computer guided by a geophysical processing specialist. Obtaining a precise image of subsurface is necessary for accurate interpretation of subsurface sections and leads to exploring the oil traps such as synclines, salt domes, faults and stratigraphic features. In this article we have fulfilled the principle steps of seismic data processing such as denoising, NMO correction, Velocity Analysis, Stacking and Migration respectively on a synthetic 3D seismic data and finally obtained an syncline that can be the potential of hydrocarbon accumulation.

Key words: Seismic processing, Oil Exploration, Velocity analysis, NMO correction, Stacking, Migration.

INTRODUCTION

Hydrocarbon reserves play a crucial role in economics and life of people in the world. There are plentiful hydrocarbon resources in the world which are not explored. In recent decades a serious competition has been emerged among the countries that have high potential reserves of hydrocarbon to explore and exploit these reserves as much as possible. The seismic method plays a prominent role in the search of hydrocarbons. Seismic exploration consists of three steps; data acquisition, processing and interpretation. Among these steps, processing of seismic data is an indispensable step that plays a vital role in exploration seismology. After data acquisition, data should be processed. The goal of seismic processing is to obtaining an explicit image of subsurface section. Oil and gas corporations are in rigorous competition to achieve better images of subsurface structures because with a good processed seismic section, the interpretation of them will be easier and the contingency of presence of hydrocarbon in the region will be improved so the interpreter announces the accumulation of hydrocarbon with less error and the expenses of hydrocarbon exploration will be decrease considerably. Processing geophysicists use computer programs to test and revise the data continuously. There are various softwares which provide the ability of processing the seismic data in the most user friendly possible state. But it can be said that the basis of all of these softwares are some complicated mathematics that are applied on the data in different ways to achieve the sharpest and the closest image of the subsurface structure. MATLAB is a powerful tool to examine that mathematical basis in order to understand the concept of making a clear and applicable image from a raw data that is nothing but some ambiguous signals. A processing flow includes major or optional steps that can be done based on the required quality and resolution on the output. In this article we applied some processing steps on a 3D seismic data and finally obtained a syncline that is ready to interpretation. It can be prone to have hydrocarbon.

Implementation of Processing Steps on 3D Seismic Data

A synthetic data set including 200 sources and 200 receivers which have recorded 481 time samples with sampling interval of 0.0063s is used for our processing flow. The separation interval of sources and receivers is 12m. It has been considered that all the corrections and noise reductions have been already done on the data set so we have these steps to achieve the desirable output:

1-CMP sorting
2-Velocity Analysis
3-NMO correction
4-Stacking
5-Migratin

CMP sorting is probably the most important gathering order which includes all of the traces received from one Common Mid-Point (CMP). These traces contain information from the same sub-surface point for horizontal reflectors. The number of CMPs for our data set is 400, and the maximum possible fold is 200. Figure 1 shows CMP gather number100.

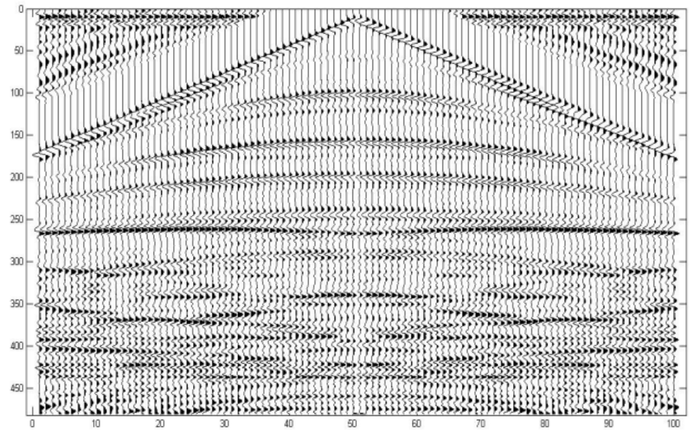

Figure1. CMP gather number 100

The next step is velocity analysis to obtaining appropriate velocity for NMO correction. The aim of the velocity analysis is to find the velocity that flattens a reflection hyperbola, which returns the best result when stacking is applied. We should find appropriate velocities and intercept times for hyperbolas fitting our reflector ones in CMP gather to flatten them. For this, we use the method of analysis of velocity spectra using semblance formula. We need to pick the peaks of energy in the velocity spectrum to obtain both the intercept time and velocity corresponding to each reflector. For more reliable picks we have done one additional step, in which we plot a hyperbola with the picked intercept time and velocity on the CMP gather just beside the velocity spectra (figure 2, the white hyperbola with intercept time of nearly 1s) to see whether it fits the reflector hyperbola or not.

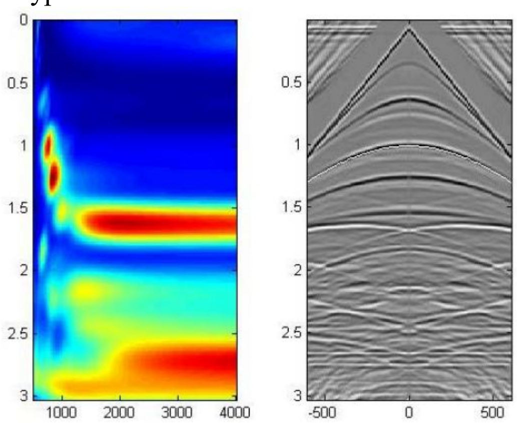

Figure 2. Velocity Spectrum and Hyperbola fitting for picking desired time and velocity for NMO correction

Next step is NMO correction. The principle of NMO correction is aligning the reflections using the correct velocities and travel times achieved by velocity analysis, such that the events are horizontal.
Figure 3 shows the CMP gather number 100 after NMO correction.

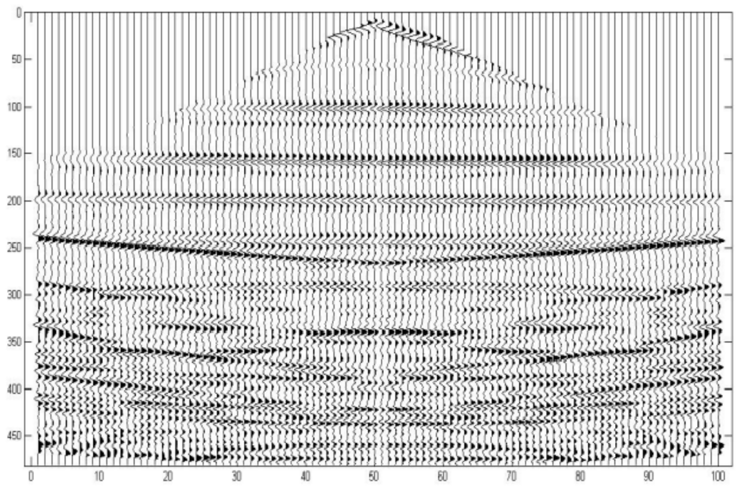

Figure 4. CMP gather number 100 after NMO correction

Next step that is one of the simplest but most important stages of the seismic processing sequence and improving data quality is stacking. Stacking is a processed seismic record that contains traces that have been added together from different records to reduce noise and improve overall data quality. The basis for reduction of noise using stacking is that the random noise which is distributed over traces will cancel out each other by summing all traces together, but coherent events will improve each other.
A CMP stacked section is often regarded as a zero offset section, especially during data be migrated. The final stacked section for all 400 CMPs is shown in figure 4. This section needs to be migrated. As it is clear, there is a butterfly shape in this section. After applying migration we can see a syncline that can be interpreted as a trap for oil accumulation.

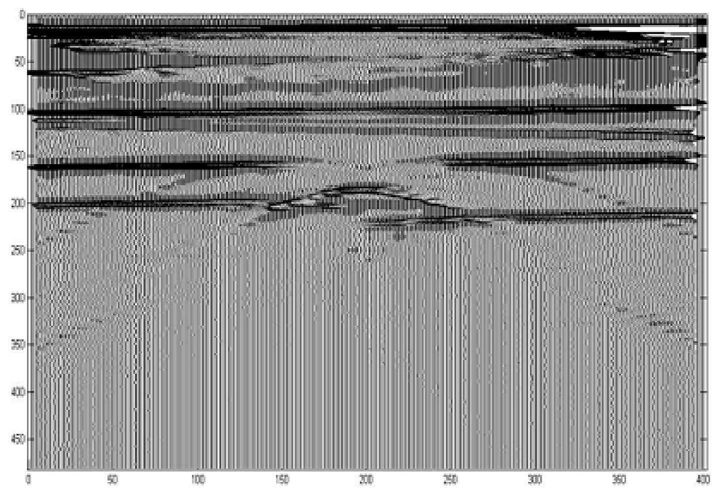

Figure 4. Final Section for all 400 CMPs

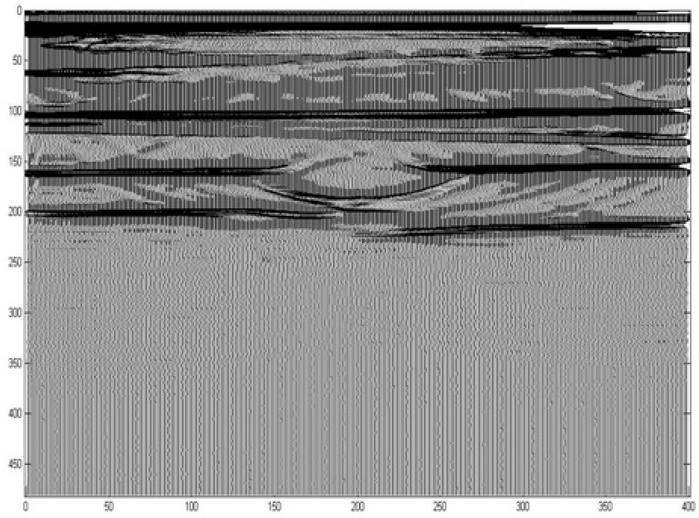

Figure5. Final Section after Migration

CONCLUSION

Exploration seismology plays a vital role in exploring hydrocarbon resources. Nowadays all of oil and gas corporations compete to obtain much clear and obvious picture of subsurface structures. Processing steps should be applied on seismic data to obtain an interpretable image of subsurface structures. The better processed seismic section, the most accurate section for interpretation and consequently more probability in detecting hydrocarbon resources. In this paper we applied different steps of processing on a 3D seismic data and finally obtained a Syncline that can be interpreted as a hydrocarbon trap.

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