

Delineation of seismic reflectors in Miano area

Khaista Rehman¹, Muhammad Manawer¹ and Sajjad Ahmed²

¹National Centre of Excellence in Geology, University of Peshawar

²Department of Geology, University of Peshawar

Abstract

The Miano area is located in lower Indus Basin of Pakistan. The research targets the method of seismic data processing and seismic data interpretation to delineate seismic reflectors using 2-D seismic and well data. Appropriate velocity formulas (root mean square velocity, interval velocity, average velocity and mean average velocity) are used in seismic data processing. The velocity analysis of the region show vertical and lateral variation in velocity. Second equation of motion is used to find depth calculation. Seismic interpretation has resulted in seismic time and depth sections, which helps to understand true picture of sub-surface. Synthetic seismograms are used to correlate the seismic reflectors, from comparison to the results from seismic data interpretation. The processing, interpretation and comparison results in six reflectors and are named as Siwalik, Ghazij, Upper Goru, top of Lower Goru, Chiltan Limestone and top of Jurassic.

Keywords: Velocity analysis; Seismic time section; Seismic depth section; Synthetic seismogram; Miano.

1. Introduction

This study pertains to investigate the 2D seismic interpretation of seismic line P2092-112 of Block 20 (Miano) area which is situated in Sindh province (lower Indus Basin) (Fig. 1). It is located at Latitude 27.32° N and Longitude 69.27° E. Structurally Indus Basin divided in to upper (Kohat and Potwar) and Lower Indus Basin (Kirthar and Sulaiman). Lower Indus Basin is further divided in to Central Indus Basin and Southern Indus Basin. Southern Indus Basin is bounded by Sargodha high in the north, Kirthar and Sulaiman range in the west, offshore in the south and Indian shield in the east.

Pakistan is tectonically characterized by two tectonic plate boundaries (the Eurasian Plate and Indo-Pakistani plate), and the under thrusting of the Indo-Pakistani Plate underneath the Eurasian Plate is producing compression tectonic features (Kazmi and Jan, 1997). The results are in the form of the spectacular mountain ranges of the Himalaya and a series of foreland fold-and-thrust belts (Kazmi and Jan, 1997).

The Central and Southern Indus Basins are divided by Jacobabad and Mari- Kandhkot highs, which are collectively known as the Sukker Rift.

The High has been active since Jurassic and Paleocene strata are absent alongside the crust and its adjoining region. The main purpose of this research is to describe procedure and functionality of a seismic system to identify geological information in the study area. This study explains: velocity analysis, analysis of seismic time section, generation of depth section to identify various reflectors in the region and to analyze structural picture and synthetic seismogram generation.

2. Seismic data

2.1. Acquisition and processing of seismic data

The seismic data acquisition is the sum of seismic lines and wells. The base map of the study area is shown in (Fig. 2) to represent the seismic data. This Figure shows the orientations of seismic lines and the corresponding points at which seismic data were obtained, to show explanation of seismic data. The data is acquired and processed by Acquisition company: S.S.L (Seismograph Service Limited) (Party NB 115) and processed and operated by OMV, Pakistan. Four seismic lines P2092-110, P2092-112, P2092-113, and P2092-121 are shown. The seismic line P2092-112 is used to analyse geological information of the Miano area. Miano-

02 well is also shown in the (Fig. 2) at the location where seismic line P2092-110 intersects the seismic line P2092-113. The nature of these lines is shown in Table 1.

In seismic detection it is necessary to detect vibration amplitude as small as 10-8 inches. In seismic crew in the field, we use sophisticated seismic instruments and recorders with tolerable sensitivity, large dynamic range, and suitable frequency response for signal detection (Lillie, 1999). Geophone is the main and used detecting device in the field (Al-Sadi, 1980). The analysis of acquisition has involved various geophones configurations on the Earth's surface or seafloor. Different energy sources, like vibrator, dynamite, or an air gun are used to generate seismic signal, while the receiver configuration records the resulting seismic response (Kearey et al., 2002). Analogue seismic data as well as digital seismic data are used in the survey of acquisition. The seismic signal was provided by source vibrator.

The array length was 88.75m and recording was done with SN- 368 (Geophones) and vibrator spacing was 15m.

For an optimal presentation of the seismic section, processing was applied (Yilmaz, 2001). Computer programs are designed for seismic data processing to operate various steps and extract useful information using raw seismic data (Rehman, 1989). In this method, we process and improve the raw seismic data collected in the field and use this meaningful information for further geological interpretation (Al. Sadi, 1980). Careful selection of acquisition parameters is essential for seismic data processing output. Surface conditions studies have supplied to present some additional and considerable effect on the value of field data (Dobrin and Savit, 1988). The processing steps consist of filtering of seismic data, static corrections, stacking process and inversion (Yilmaz, 2001).

Table 1. Showing the nature of seismic lines.

S/No.	Line No.	Line Nature
1.	P2092-110	Strike Line
2.	P2092-112	Strike Line
3.	P2092-113	Dip line
4.	P2092-121	Dip line

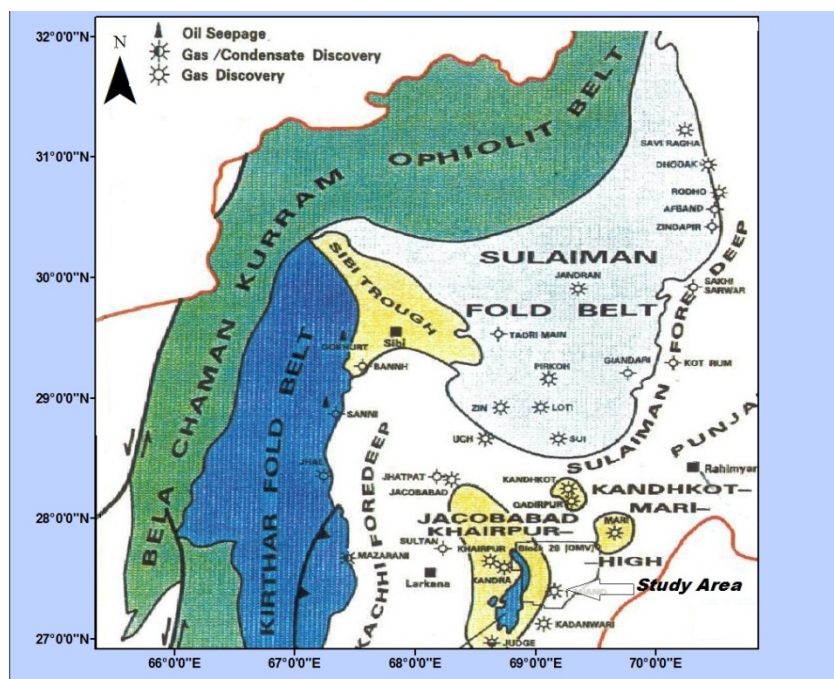


Fig. 1. Location of study area (Modified after Krois et al., 1998)

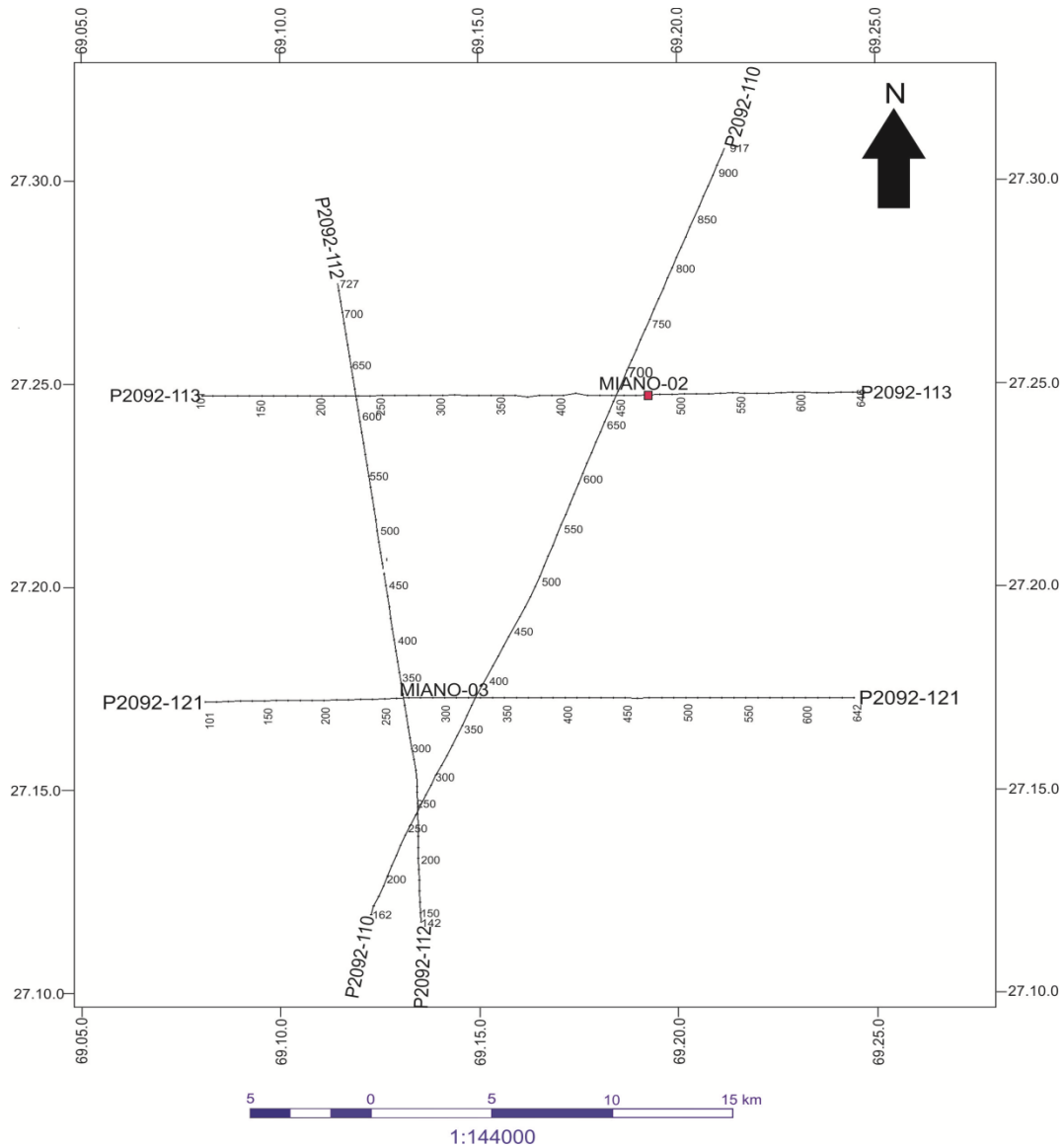


Fig. 2. Base Map of the study area showing locations of MIANO-02 and MIANO-03 wells.

2.2. Seismic velocity analysis

The most important step in seismic interpretation is the accurate calculation of Primary wave (P-wave) velocities in different rock types, while taking into account an accurate velocity parameter, the processing and interpretation techniques incorporate accurate measurements. Principle objective of seismic velocities is to convert time section into depth section to have structural as well as lithological interpretation. The role of seismic velocities in both data processing and interpretation is very helpful such as: correct depth, stacking, migration, probable lithologies and porosity calculation. Post stack data

has been used for velocity analysis. Velocities are taken from the tables given on seismic section and are used in all Velocity analysis and also in Depth section. The compressional and shears velocities in rocks (Robinson and Coruh, 1988) are given in Table 2.

In seismic prospecting, we deal with a medium, which contains series of layers within the Earth's surface having different velocities. The specification of type of velocity used in the study is very important. In seismic methods, the word velocity is used in a number of ways. The most frequent are root mean square (rms), interval velocity, average velocity and mean average

velocity. RMS may be derived approximately from common depth point (CDP) shooting. Interval velocity should be defined within selected time interval, while average velocity is calculated from the surface down to the reflecting interface. Mean average velocity shows the expected value of all the average velocities at any specific time, and in general indicate that the average velocity is in increasing fashion with respect to time. It is used to calculate the mean average depth of seismic section. We processed the Root Mean Square Velocity functions given on a seismic section with the help of K-tron VAS (Velocity Analysis System) to compute interval and average velocity functions. By further process with the help of K-tron VAS (Velocity Analysis System) software we got Mean Average Velocity graph. It is used to calculate the mean average depth of seismic section.

These four velocities are given in Equations (1) → (4), (Fig. 3) and graphs for these velocities are shown in (Fig. 4 and 5).

$$V_{RMS,n}^2 = \frac{\sum_{i=1}^n V_i^2 t_i}{\sum_{i=1}^n t_i} \quad (1)$$

Where V_1, V_2, \dots, V_n are interval velocities and t_1, t_2, \dots, t_n represent two way time to the respective interfaces.

$$V_{avg} = \frac{\sum_{i=1}^k h_n}{\sum_{i=1}^k t_n} \quad (2)$$

Where depth is h_n and travel time is t_n and $n = 1, 2, 3, \dots, k$

$$V_{int,n} = \frac{h_n}{t_n - t_{n-1}} \quad (3)$$

Where h is the layer thickness and t is two way travel time

$$V_{int,n}^2 = \frac{V_{rms,n}^2 T_n - V_{rms,n-1}^2 T_{n-1}}{T_n - T_{n-1}} \quad (4)$$

T denotes two ways travel time to horizontal interfaces and V_{RMS} is the Root Mean Square Velocity.

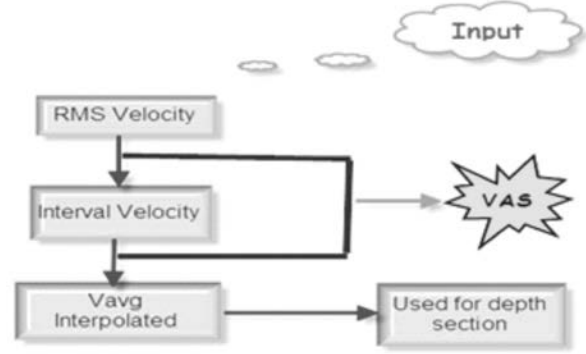


Fig. 3. Flow chart of the generation of Velocities.

2.2.1. Iso velocity map

A section which is created by plotting the CDP's against the average velocities and indicates the lateral and vertical variations of the same velocity layers at different CDP's is called Iso-velocity map. We generated the Iso Velocity Map by using the K-tron VAS (Velocity Analysis System) and Surfer software's (Fig. 7). The procedure is started from conversion of RMS velocity into interval velocity and interval velocity into average velocity using K-tron VAS (Velocity Analysis System) software. We then interpolate the average velocity and contour map (Fig. 6) is created in computer software Surfer. The lithological information about study are discussed in Sections 3.1 and 3.2.

Table 2. Compressional and shears velocities in rocks.

Material and Sources	Compressional Velocity (m/sec)	Shear Velocity (m/sec)
Granite	5520-5580	2870-3040
Granodiorite	4780	3100
Diorite	5780	3060
Gabbro	6450	3420
Basalt	6400	3200
Sand Stone	1400-4300	2600
Lime Stone	1700-6060	2880-3030

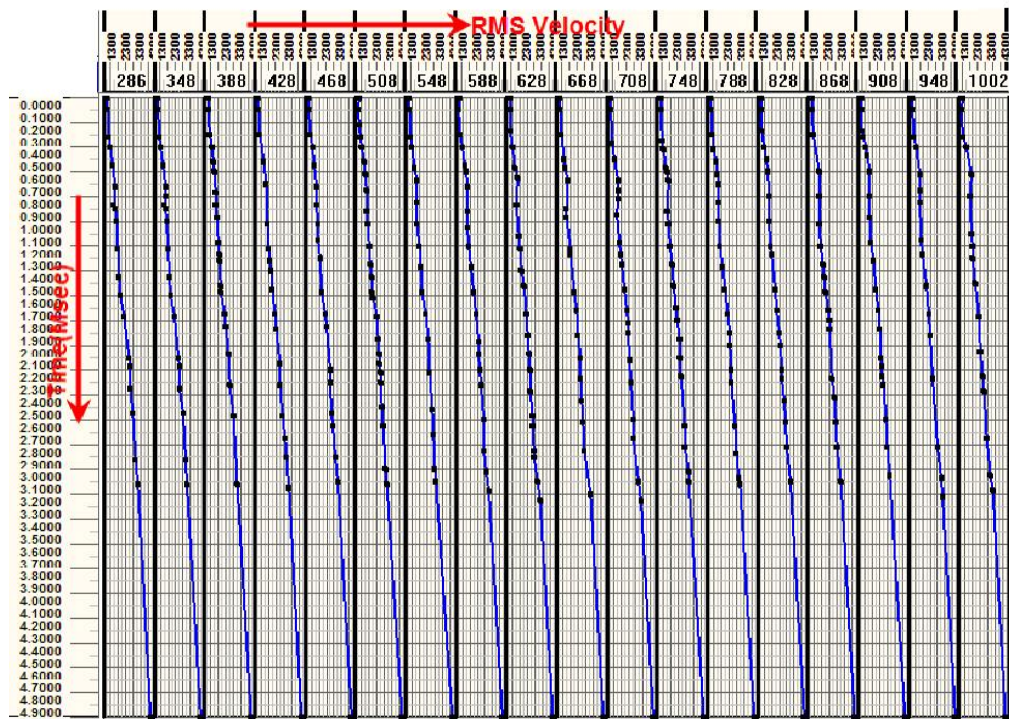


Fig. 4(a). RMS velocity of the line P2090-112.

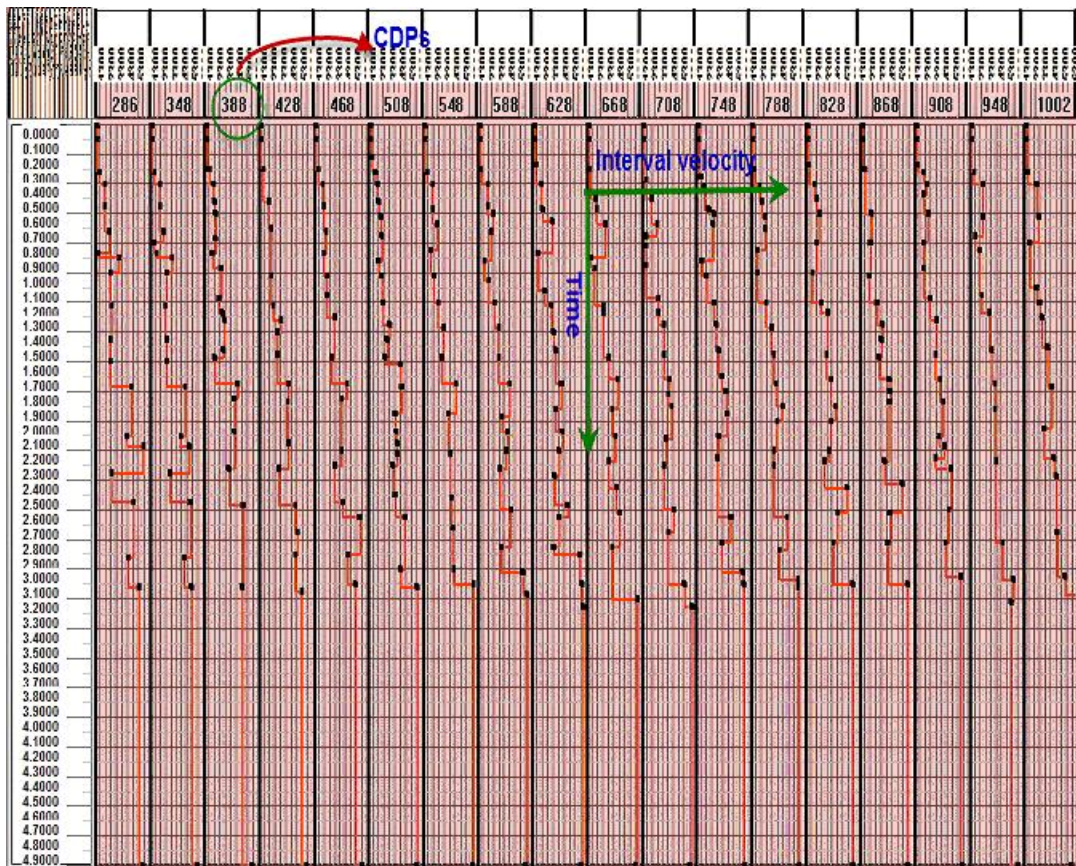


Fig. 4(b). Interval Velocity of the line P2092-112.

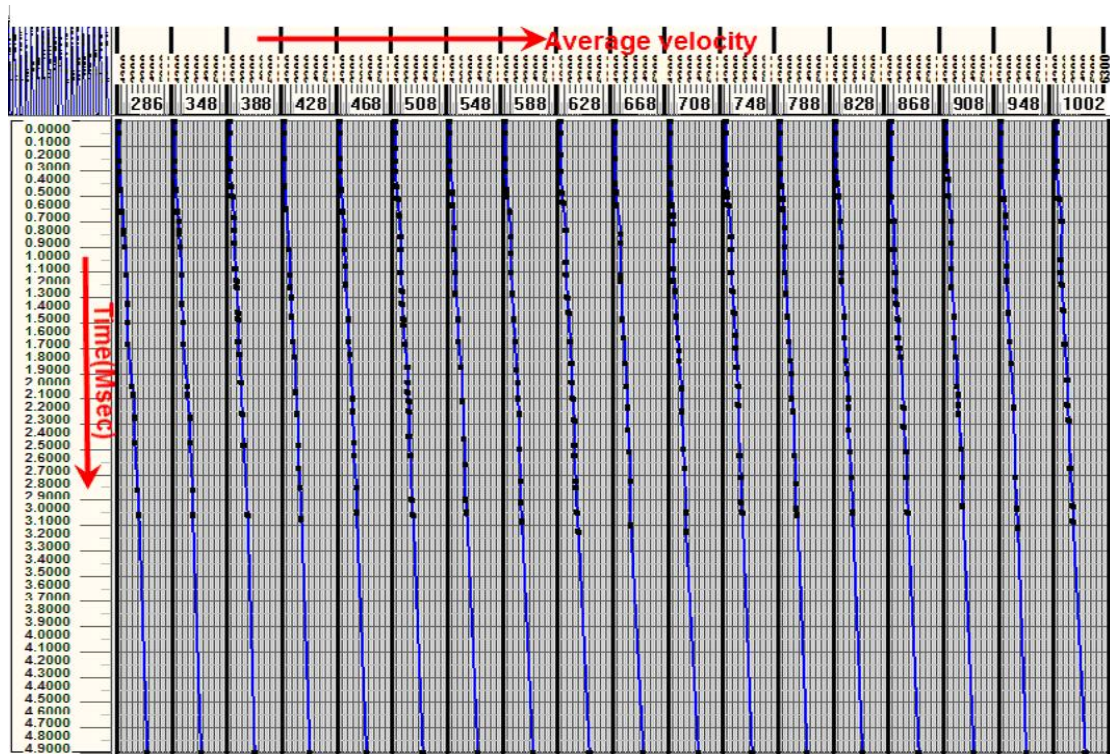


Fig. 5(a). The average velocity of the line P2092-112.

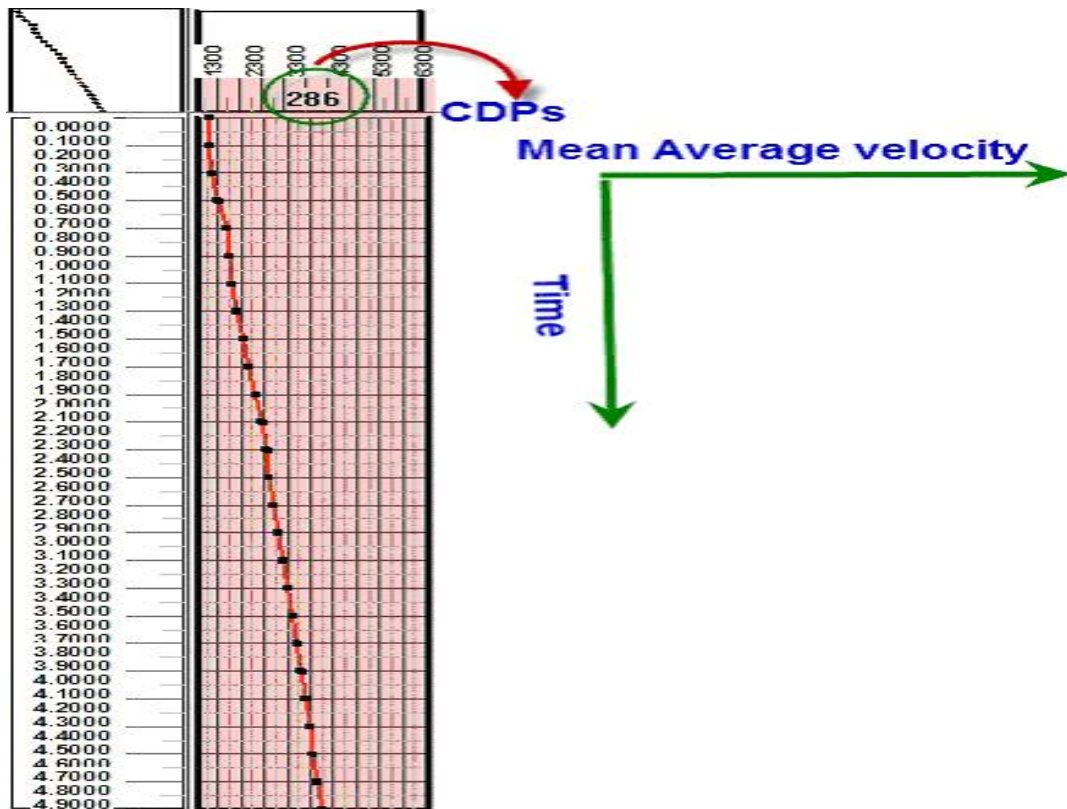


Fig. 5(b). Mean Average Velocity Graph of the line P2092-112.

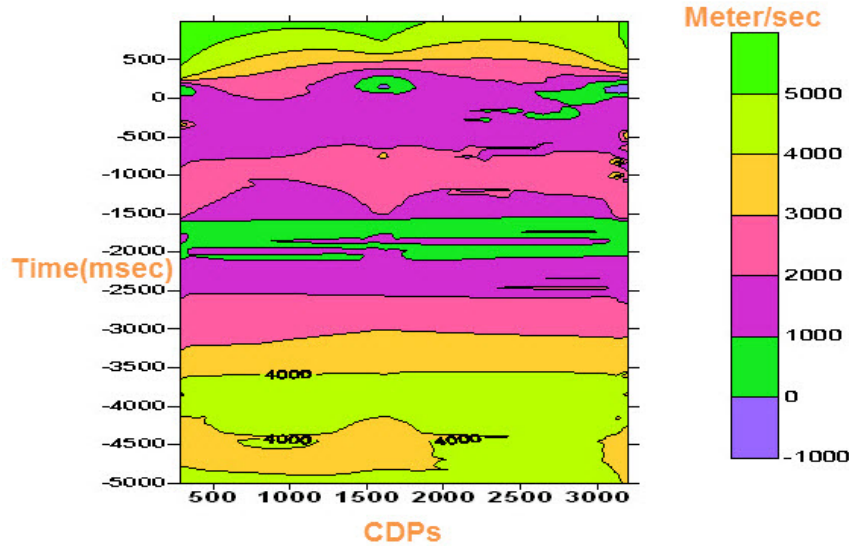


Fig. 6. Showing the Iso velocity Contour Map.

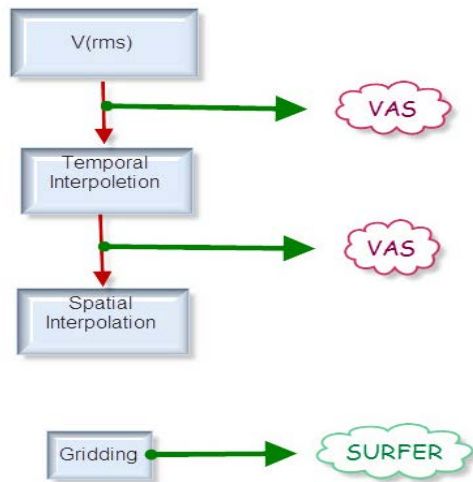


Fig. 7. Flow chart of the generation Iso-Velocity contour map.

3. Results

3.1. Seismic time section

A seismic time section is a section where the vertical scale represents the arrival time and horizontal scale represents shot points (Badley, 1985). A seismic is picture or diagram of a cross section of the earth, composed of data from different seismic shots. In its usual form, it is made up of many wiggly line, or trace, show a modified version of the vibration of the ground at a line. A wiggle on a trace is an indication of

difference between two kinds of underground rocks (Heiland, 1968). These rocks may differ from each other with respect to their physical properties and chemical properties. Physical properties mean that they differ in their densities and modulus of elasticity and chemical properties mean that they may differ in their chemical compositions. The rocks in the sedimentary basin, like southern Indus basin, are usually in the form of layers of wide extent. So wiggle on one trace is usually come with a related wiggle on the next trace and so on. A continuous line of the side by side wiggles is a seismic horizon.

We try to pick the prominent and continuous reflection on seismic time section. To pick a reflection the most evident indication of the reflection is the dark band of the filled in peaks. Reflection events of interest are usually color-coded initially and labeled as, for example red-reflector, blue-reflector, until their geological significance is established. To color a reflector, it is easy to decide to pick a peak and then color the trough area of a particular horizon.

Indeed, each reflector's time following the marking horizons and faults are noticeable at various shot-points. The production of time section involves the plotting of reflector's two-way travel time results and fault data on y-axis on section against the shot points on x-axis. Seismic section in time domain is the developed section of reflectors, which shows subsurface. Time section of the Line P2092-121 is show in (Fig. 8).

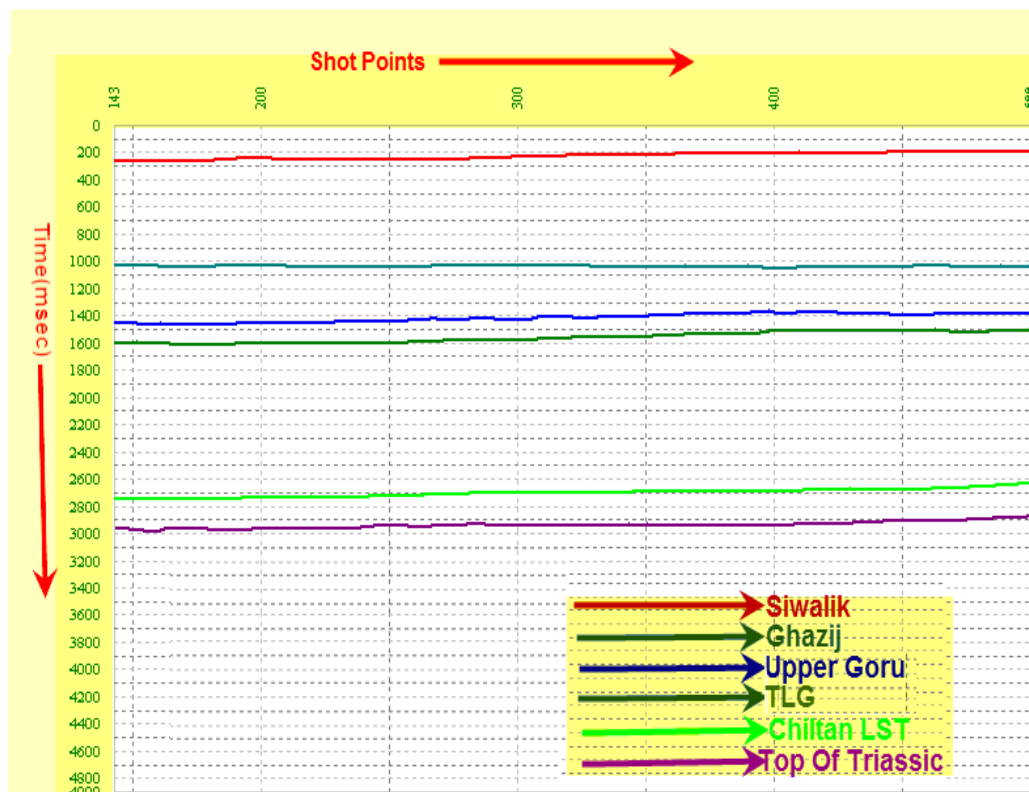


Fig. 8. Seismic Time Section of Line P2092-112.

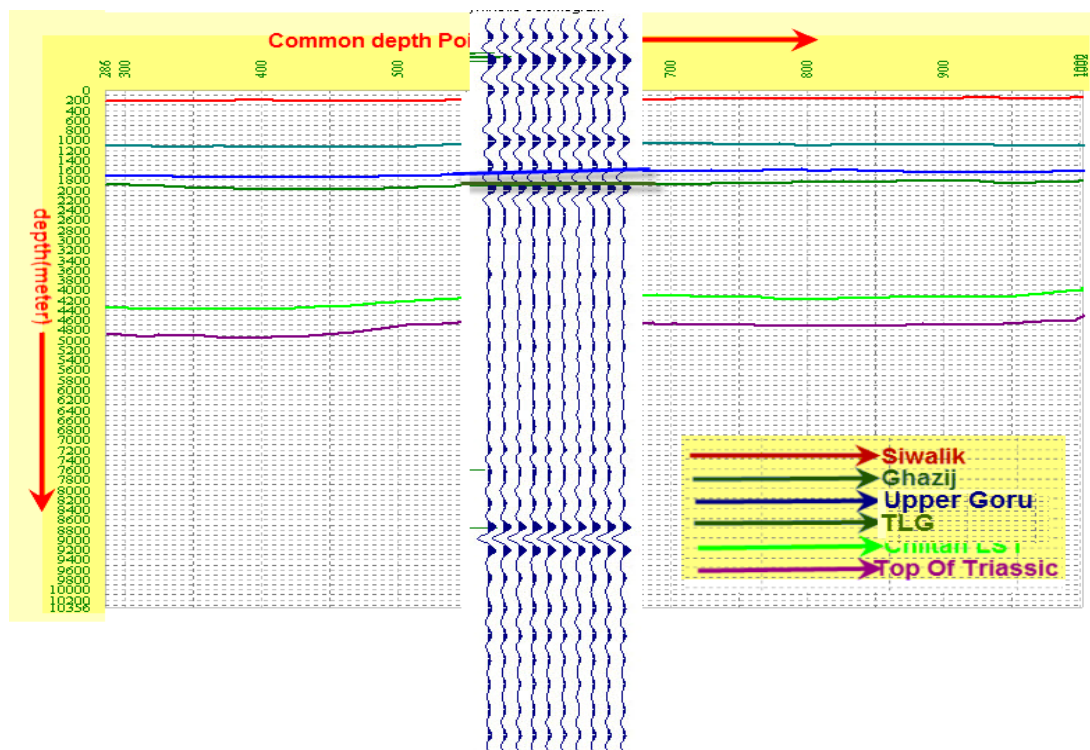


Fig. 9. Showing the correlation of Synthetic Seismogram with Lower Goru.

3.2. Generation of synthetic seismograms

Synthetic Seismograms are used to correlate well log data with the information obtained from surface seismic and thus to refine the geological interpretation of seismic data. We use well Miano-2 to carry out the current study. The objective of generating synthetic seismograms is to observe whether the synthetic seismogram correlates with seismic data recorded at the study area and to conform interpretation. Klauder wavelets are often used to generate synthetic seismic records in case of vibroseis. Other wavelet like Ricker wavelet is used for Dynamite source. The inputs to generate the synthetic seismograms in wavelet software are frequency of 25 Hz, sampling interval of 2 sec and vibroseis source. This method of generation of synthetic seismogram is implemented in wavelet software. The results are shown in (Fig. 9). This Figure compares seismic interpreted data with well data. The correlation shows a good matching between the synthetic seismograms with the real seismic data recorded at the study area. It also confirms our lithological interpretation of the seismic line P2092-112. The well does not go up to Chiltan formation in the present case and in general not many wells are drilled till Chiltan formation in Lower Indus Basin. It only goes up to Grou formation according to well data of Miano-2. Furthermore, Chiltan is a bright reflector in seismic section and synthetic seismogram.

3.3. Seismic depth section

Seismic depth section requires conversion of the seismic time data to the depth data (Parasnis, 1997; Sheriff, 1999). The conversion assumes the following form:

$$D = VT$$

Where D, V and T are the depth, velocity and one way travel time respectively. Vertical unit of seismic section represents two-way time, and it does not show the true picture of sub-surface structure, so we convert the time section into depth section. In computer program X- works the depth section is obtained using generation of time section and then multiply x-dimension of the cross section by 2.

4. Conclusions

The following conclusions can be drawn from the current work presented above:

- 1) Six reflectors are marked and named. Reflector 1, Reflector 2, Reflector 3, Reflector 4, Reflector 5, Reflector 6 are named as Siwalik, Ghazij, Upper Goru, TLG, Chiltan Lst and top of Jurassic respectively.
- 2) The velocity maps show vertical and lateral variation in velocity. There is general trend of increase in velocities with depth due to burial and compaction.
- 3) Time to depth conversion of seismic section give a true picture of sub-surface structure.
- 4) The depth section is compared with synthetic seismogram analysis.

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