2-D SEISMIC INTERPRETATION OF SUKKUR AREA,CENTRAL INDUS BASIN PAKISTAN

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ABSTRACT

Aim of this dissertation is to interpret 2D-Seismic Reflection time sections of the sukkur Area (Sindh Province) Pakistan. This seismic sections are Post-stacked time migrated sections and were provided by the Department of Earth And Environmental Sciences, Bahria University Islamabad and the lines bear the title P2291-OMV-19 oriented in NE-SW direction, P2291-OMV-14 oriented in N-S direction and P2291-OMV-41 oriented in N-S direction. OGDCL acquired data in October 1991. The velocity information is in the form of RMS, DIX interval and DIX average at different times is given, and is provided at selected S.Ps. For interpretation of the Seismic sections, five horizons R1,R2,R3,R4 and R5 were marked on line P2291-OMV-19 which were then shifted to Lines P2291-OMV-14 and P2291-OMV-41 with the help of seismic tie lines, these horizons were marked on the basis of prominent reflections from subsurface horizons due to changes in lithology and diffractions. Using the RMS velocity given in the velocity panels on seismic section for selected shot points, I calculated the times on constant velocity interval of 100m/sec.From Seismic Section, arrival times (two ways) of each marked reflector are determined. Using these arrival times, Time Sections have been prepared for the three selected lines. Also using these arrival times, I calculated the average velocity for these times on mean line graphs and then the depth of each reflector has been calculated using S=(v*t)/2 and is represented in Depth Sections of the three selected lines. Depth Sections provide a reliable picture of reflectors and structures present in the subsurface of the area. Well correlation is also done, which satisfy the calculated depths, so horizons have been marked. Interpretation of the Project Area shows that, extensional regime and calm environment prevails in the area. Reflectors are almost flat lying, whereas Horst and Graben structures have been found.

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CHAPTER # 1

INTRODUCTION

1. INTRODUCTION

Most of the mysteries of the universe as they stay undiscovered, we try to explore them by knowledge ALLAH has given us. It is the case with seismic method with which we try to image the subsurface mysteries in the earth, shallow or deep. Seismic method is the most direct and least ambiguous geophysical method for subsurface litho structural analysis.

Sukkur area administratively lies in the NW of Qadirpur area and North of the khairpur area, Sindh Province. Sukkur is the nearest major town. The area is extensively farmed and contains irrigation channels of various sizes.

The seismic survey was carried out in Sukkur area Block 22 by OMV party no 5 in 1991. The data acquisition and processing were made by selecting appropriate field and processing parameters. This dissertation pertains to the interpretation of the migrated time sections of line numbers

P2291-OMV-19	30 FOLD NE-SW (Strike line)
P2291-OMV-14	30 FOLD N-S (Dip line)
P2291-OMV-41	30FOLD N-S (Dip line)

The base map of my project area is shown below in Figure 1.1.

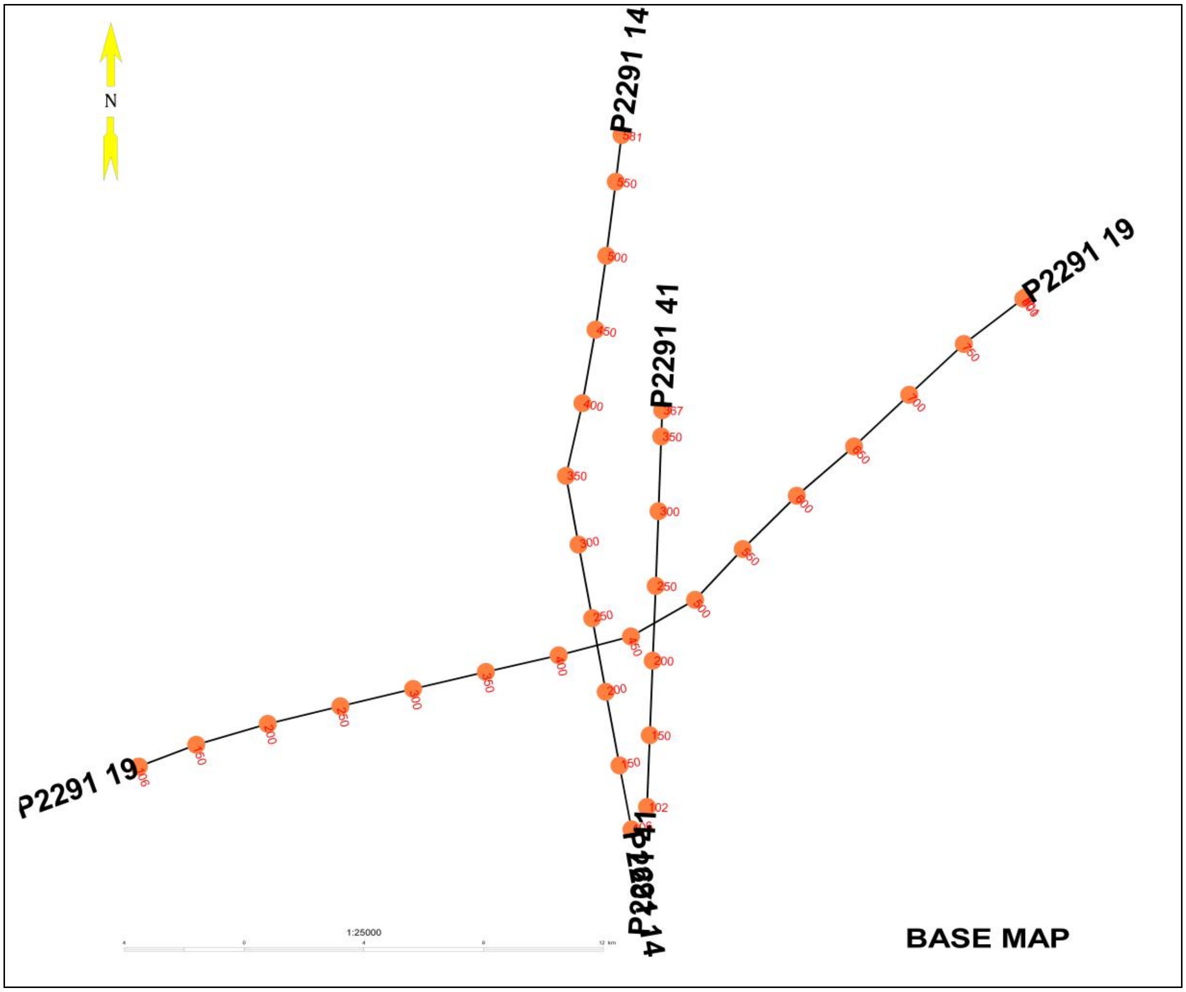


Fig.1.1 Base Map of study area

1.1 Introduction of study area

The survey was carried out by OMV party no 5, shoted from 15/10/91 to24/10/91. It is Located in Sukkur area with total Area of 293 Km^2. The main reservoir rock in this area is Sui Main limestone while the secondary objective is Cretaceous sand.

1.2 Geographic boundaries

Geographic boundaries of the Sukkur area are as follow:

- At north west of study area is Shikarpur.
- At south of study area is Khairpur.
- At north east of study area is Ghotki.
- At west of study area is Larkana

Fig. 1.2 Location of the study area adopted form map.web.mapquest.com

1.3 Objectives of research

The main objectives of the research are

- To understand the structural style and tectonic of the area.
- Marking of reflectors on seismic section in correlation with the well data.
- Calculate two way travel times for the selected horizon to develop time contour maps.
- To calculate the depth of each interface using the provided average velocity information.
- To study the effects of the velocity variation along the profile and its distribution in the subsurface.
- Construction of “Depth and Time sections and contours” after calculating the depth and time of each reflector against the specific SPs.
- To interpret the available seismic data and to make structural and stratigraphic interpretation of the area.

CHAPTER # 2

Geology and Stratigraphy of the Area

2.1 General view of Indus basin

The Indus basin covers an area of about 533,500km2 and contains more than 15,000meters thick sediments ranging in age from Precambrian to recent. Oil and gas fields have been discovered in the inner folded zones of the Suleiman and Kirthar Ranges, Kohat-Potwar Plateau, Suleiman–Kirthar depression (fore deep), Karachi depression, and the Indus platform (Punjab monocline, Sukkur and Sindh monocline).

The Indus Basin can further be classified as

Upper Indus Basin	Kohat sub-Basin
	Potwar sub-Basin
Lower Indus Basin	Central Indus Basin
	Southern Indus Basin

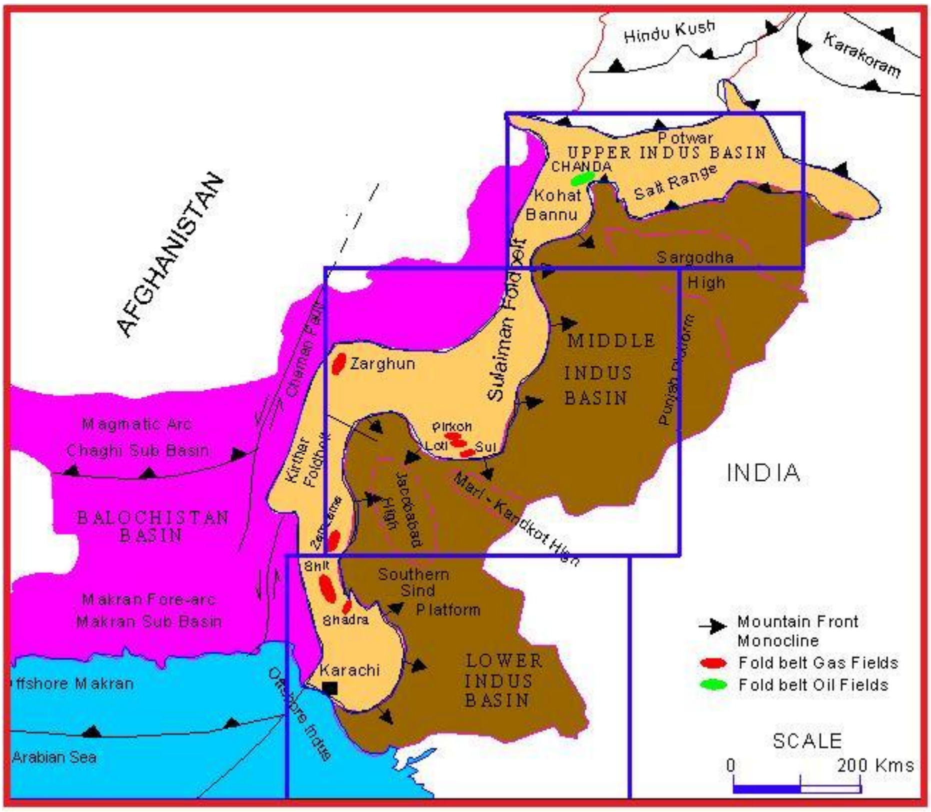


Fig. 2.1 Division of Indus basin of Pakistan (Raza et al. 1989)

2.1.1 Upper Indus Basin

This basin is located in the northern Pakistan and is separated from the Lower Indus basin by Sargodha Highs. Its northern and eastern boundaries coincide with the Main Boundary Thrust (MBT). The Western boundary of the basin is marked by an uplift of Pre – Eocene sediments and eastward directed thrusting to the west of Bannu.

The basin is further subdivided into Potwar to the east and Kohat to the west, by river Indus. Regardless of the small size of the Potwar and Kohat sub – basin they depict important facies variations. Both Kohat and Potwar Sub – basins are characterized by an unconformity between Cambrian and Permian.

Potwar sub–basin preserves the sediments from Precambrian to the Quaternary age in the subsurface and all of them are exposed in the Salt range.

In the Kohat sub – basin, west of the Potwar sub – basin, Eocene through Siwaliks strata are involved in a complex fold and thrust belt in which Eocene Salt occupies the cores of many of the anticlines.

2.1.2 Lower Indus Basin

The Lower Indus Basin is further divided into two classes

2.1.2.1 Central Indus Basin

2.1.2.2 Southern Indus Basin

The Central and Southern Indus Basin are separated by Jacobabad and Mari Khandkot highs; these are collectively termed as Sukkur Rift.

2.1.2.1 Central Indus Basin

- Punjab Platform
- Suleiman Depression
- Suleiman Fold Belt

2.1.2.2 Southern Indus Basin

- Thar Platform
- Karachi Trough
- Kirthar Fore deep
- Kirthar Fold Belt
- Offshore Indus

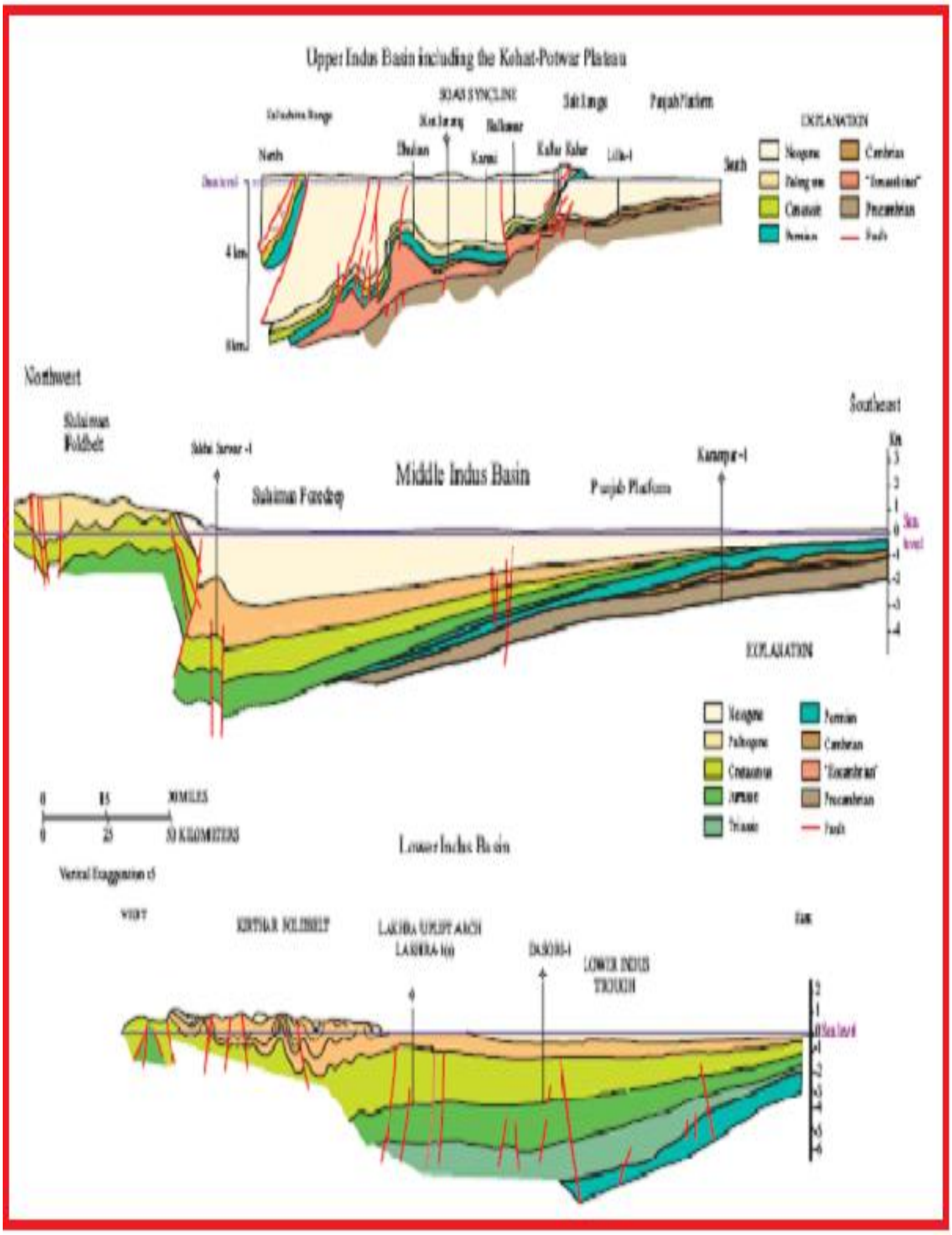


Fig. 2.2 Generalized cross sections showing structure across the Upper , Middle and Lower Indus Basin, fold belt, and Kohat-Potwar area (modified

from Quadri and Shuaib, 1986; Malik and others, 1988; Khadri, 1995; and OGDC, 1996)

2.2 Tectonics of the Central Indus basin

In central Indus basin different phases of tectonic activities are recognized. The rifting of Indo-Pak plate from Madagascar took place in the late Jurassic early Cretaceous. The deposition of lower Cretaceous fluvio deltaic sediments Sembar and lower Goru deposited over Jurassic Chilton limestone. In Indus basin resulted from this phase of rifting the upper Goru is progressively more calcareous. Overlying the Goru is the Parh limestone

Other phase of rifting occurred with the break of Gondwanaland in late Cretaceous/ Paleocene resulting block faulting in Cretaceous and Tertiary sequences and deep seated transform faults, deposition of Pab sandstone followed by uplift and erosion of the upper cretaceous sediments.

The unconformity produced by this erosion marks the boundary between Cretaceous and Tertiary. Over the unconformity in Paleocene time were deposited the Ranikot made up of sandstone, shales and Dunghan limestone.

The sedimentation was terminated as a result of the continental collision between India and Asian plates. Significant erosion resulted producing a marked unconformity and deposition of thick Molasses Siwaliks. The Tertiary sediments formed a dome shape structure over the block faulted cretaceous sediments.

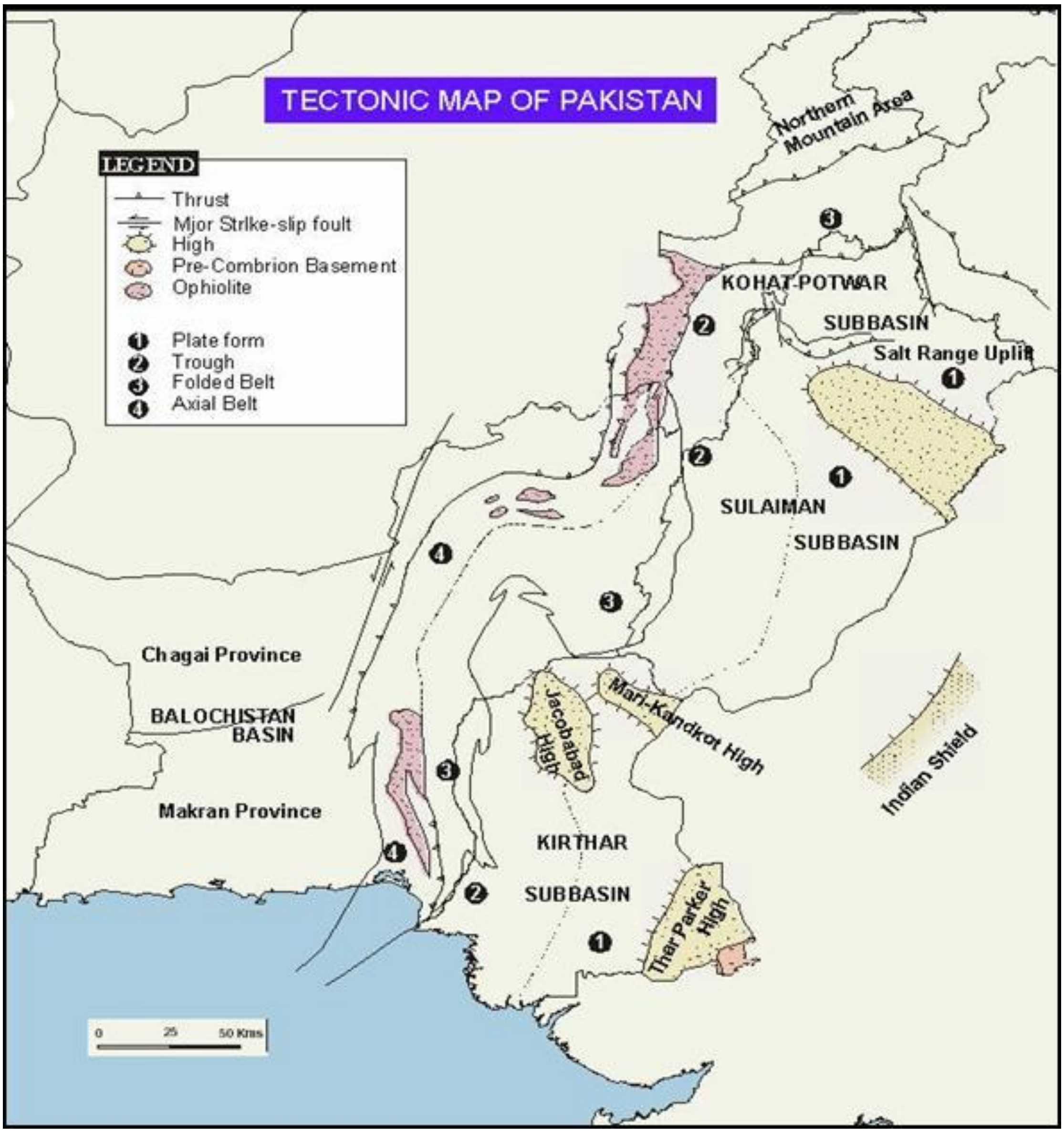


Fig. 2.3 Tectonic Map of Pakistan

2.3 Geological setting

The central Lobe of the Suleiman Fold Belt developed during the latest stages of the Indo-Pakistani and Eurasian Plate collision. A number of generally east-west arcuate anticlines are mapped, many of which are trusted on their southern margin. Structural development prior to these compress ional events is completely masked.

In contrast the Punjab platform is dominated by an increasingly steep monoclonal dip of the platform to the west. Apart from the pre-Gondwanaland break-up sediment distribution, all sedimentary units thicken and become more marine from east to west. Faulting is relatively minor, generally trending north-south and down thrown to the west. There is some evidence of minor reactivation during the Early Tertiary with a strong northwest-southeast trending wrench component.

2.4 General Stratigraphy

A Summary of Stratigraphic sequence of Southern Indus basin is given below

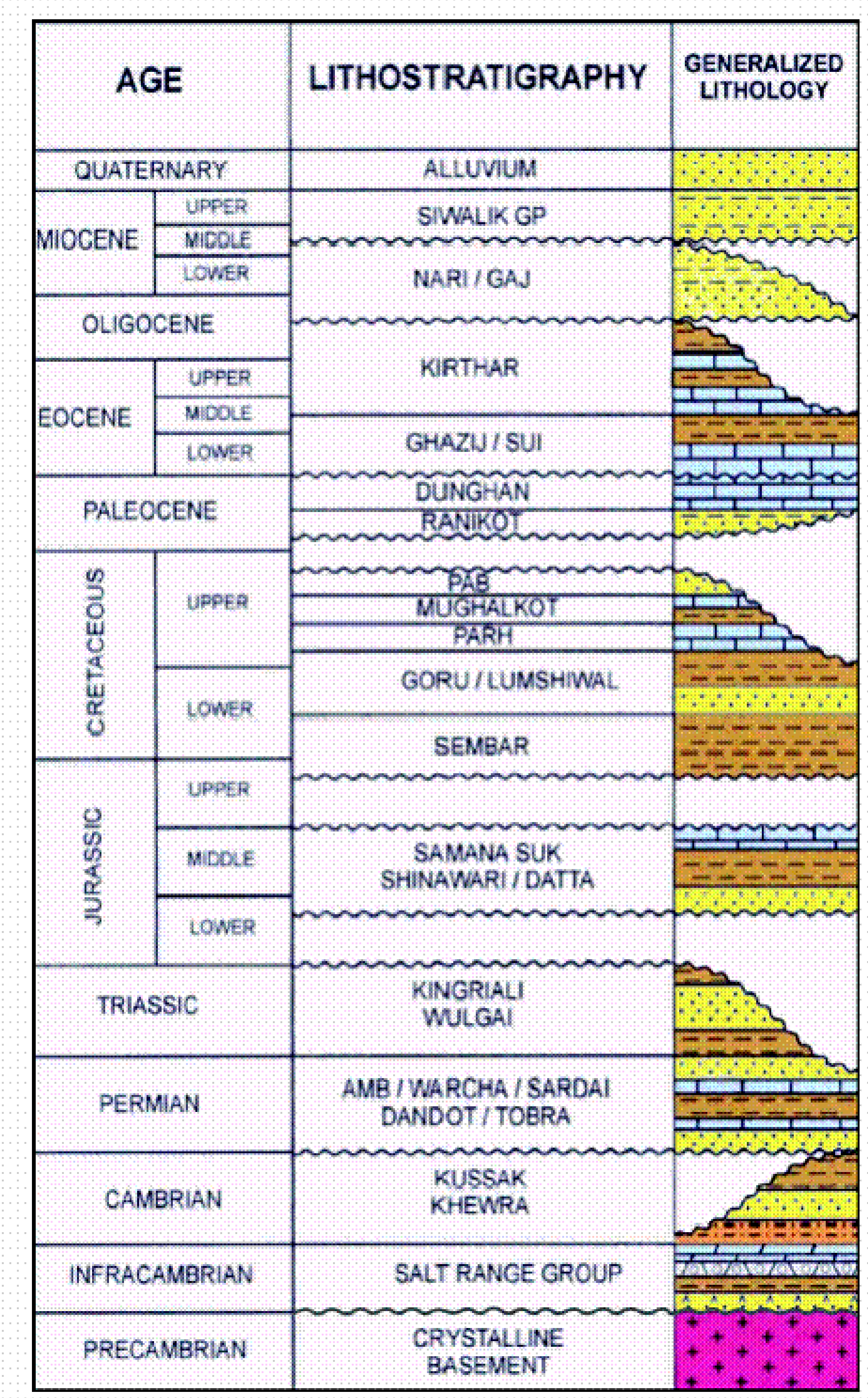


Fig. 2.4 Generalized Stratigraphy of Punjab Platform, Central Indus Basin
(Raza and Ahmad, 1990)

The strata at the surface in this area is covered by alluvium,all the lithologies are encountered in the drilled well.The Formation encountered in the subsurface are Ghazij Formation ,Sui Main limestone and Sui Main limestone of Eocene age,Dunghan Formation, Top lower Goru, Basal sand, Sember shales and upper Goru etc .

The sedimentary fill in the area is round 8500 meters (Ahmed & Ahmad, 1991), ranges probably from Paleozoic to Recent in age and is marked by number of unconformities

2.4.1 Paleozoic

It is probable that the Paleozoic sediments exist in the study area as they occur in the northeast on Punjab platform.

2.4.2 Mesozoic

The Triassic succession comprises of shale and limestone (Wulgai/Alozai Formation). The Jurassic rocks overlie the Triassic with an unconformity. The succession in ascending order comprises shale and limestone with subordinate amount of sandstone (Shinrinab Formation), limestone (Chilton Formation). The Jurassic- Cretaceous boundary is also marked by an unconformity. The oldest Createaceous strata is composed of shale (Sembar Formation) followed by sand stone and shale (Lower Goru & Upper Goru Formations). Limestone (Parh Formations) and sandstone (Pab Formation). The Cretaceous period was a time of intense tectonic activites involving rifting and rapidly northward drift of the Indian continent.

2.4.3 Tertiary

The Paleocene strata is represented by sandstone and shale followed by limestone (Dunham Formation). The Pale cone is overlain unconformable by mixed carbonate and classic litho logy of Eocene age (Lake and Kithara Formations) Lake Formation is subdivided into Sui main limestone. Ghazij shale and Sui Upper limestone.

2.5 Stratigraphy of the Study Area

Stratigraphy of the area is given as below:

(1)Ghazij Formation

Age: Lower Eocene

Litho logy: Shale with thin beds of limestone.

Shale: Greenish grey, pyretic, calcareous with occasional fossils.

Limestone: White, medium hard having thickness 8 to 10m.

Contact: Upper contact with Habib Rahi Limestone and lower contact with Sui Upper Limestone is conformable.

(2)Sui main limestone

Age: Lower Eocene.

It has following three units:

(i) Sui Upper Limestone.

(ii) Sui Shale.

(iii) Sui Main Limestone.

(i)Sui Upper Limestone

Age: Lower Eocene.

Litho logy: Limestone 100%.

Limestone: White, off-white, medium hard, fossileferous.

Contact: Upper contact with Ghazij Shale and lower with Sui Shale member is conformable.

(ii)Sui Shale

Age: Lower Eocene.

Litho logy: Shale with thin bands of limestone.

Shale: Greenish grey, pyretic, calcareous with occasional fossils.

Limestone: White, medium hard having thickness 8 to 10m.

Contact: Upper contact with Sui Upper Limestone and lower with Sui Main Limestone is conformable.

(iii)Sui Main Limestone

Age: Lower Eocene.

Litho logy: Limestone with traces of shale.

Limestone: Off-white, creamy, medium to hard, calcitic veins, marly and highly fossilferous.

Shale: Light greenish grey, light grey, laminated fossileferous.

Contact: Upper with Sui Shale and lower with Dunghem Formation are conformable.

(3)Dunhan Formation

Age: Upper Paleocene.

Litho logy: Off-white, creamy grey, medium to coarse grained limestone.

Contact: Upper contact with Sui Main Limestone and lower contact with pab sandstone is conformable.

(4)Pab sandstone

Age: Lower Cretaceous.

Litho logy: White to brown color sandstone with subordinate shale.

Contact: Upper contact with Dunghan is conformable and lower contact with Goru Formation is conformable.

(5)Goru Formation

Age: Middle to Upper Cretaceous.

Litho logy: Sand, light grey shale and some gluconitic beds of sandstone.

It has following units.

- Upper Goru
- Lower Goru
- Upper shale
- Middle sand
- Lower shale
- Basal sand
- Talhar shale

- Massive sand

Contact: Upper contact with Pab sandstone and lower contact is conformable with Sembar Formation.

(6)Sember Formation

Age: Upper cretaceous.

Litho logy: Green to greenish grey shale + thin bands of sandstone and siltstone. Shale is highly fossileferous.

Contact: Upper contact with Goru Formation is conformable and lower contact with Chiltan Limestone is disconformable.

(7)Chilton Formation

Age: Middle to Late Jurassic

Litho logy: Dark grey to black, oolitic to pisolitic limestone.

Contact: Upper contact with Sembar Formation is disconformable and lower contact with Shrinab Formation is conformable.

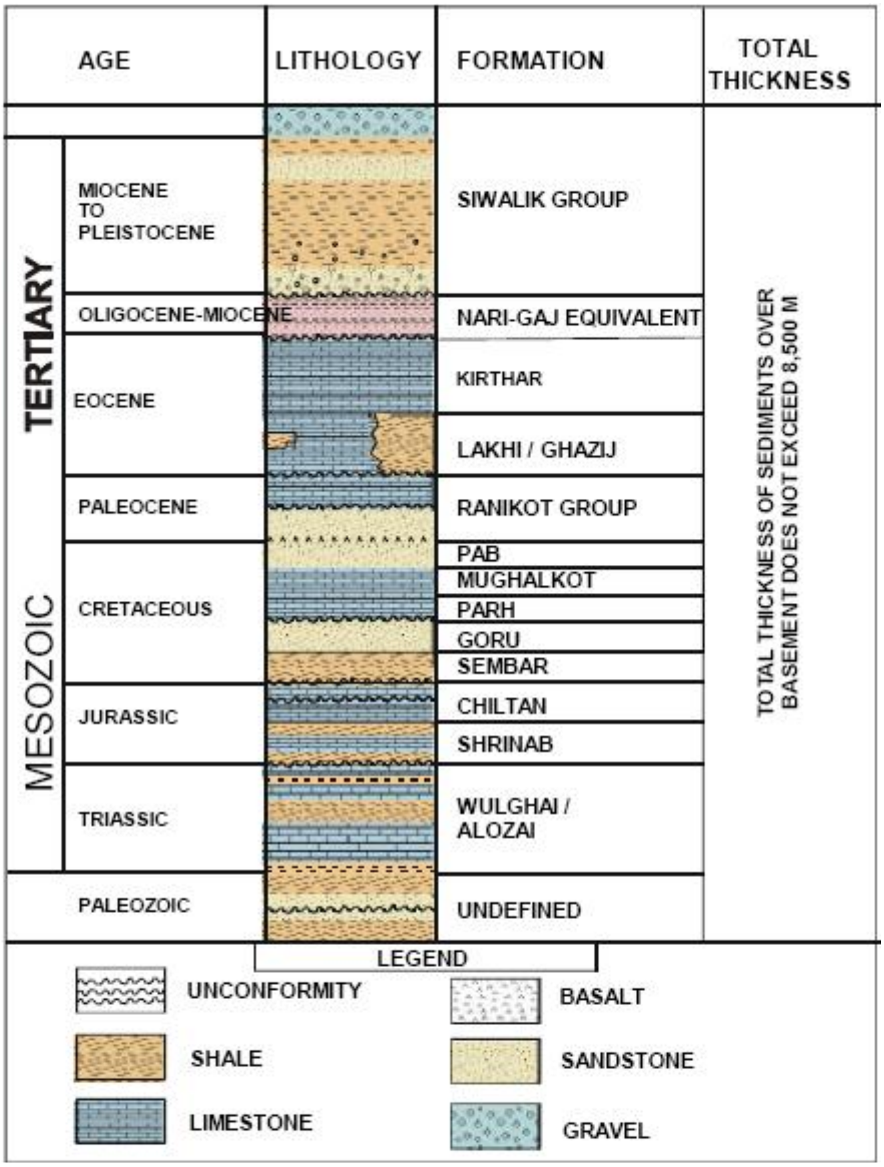


Fig. 2.5 Generalized Stratigraphy of Area (Source: OGDCL)

CHAPTER # 3

Petroleum System

3.1 Petroleum geology of area

The producing reservoirs in the study area are the carbonates of Eocene (Sui Main Limestone) and clastic of Cretaceous age (Lower Goru Sandstone & Pab Formation). Sui Main limestone and Lower Goru sandstones are producing in various parts of region under investigation. A number of studies exist in the exploration companies' files and public domain (mostly unpublished) that have documented the depositional framework and reservoir stratigraphy of the Sui Main limestone Lower Goru in this area.

3.2 Trapping mechanism

Trapping mechanism is mainly provided by the traditional tilted fault blocks which are expected in these areas. Horst structures developed in the area act as very suitable traps for hydrocarbon accumulation. The possibility of Stratigraphic traps in the form of sand lenses cannot be ruled out. Transgressive shales of the Ghezij, upper and lower Goru Formation provide effective sealing mechanism for the entrapment of hydrocarbons in the lower Goru sand reservoirs (Quadri, 1986; Viqar-un-Nisa, 1986).

3.3 Source rock

Sember is the prime source of hydrocarbons in Sukkur block due to significant content of organic matter, oil/gas prone Kerogen (type 2 and 3) and adequate thermal maturity. Lithologically, it is composed of silty shales and siltstones. The environments of deposition of these shales were deep marine, associated with turbidities. Total organic carbon contents (TOC) are generally higher than 1%.

The Shales with in Goru Formation is also reported to have a minor source potential.

3.4 Reservoir rocks

The sui main resesvior is productive in Kandkot, Hamza, Qadirpur, Hasan, Sadiq, Kandra & Khairpur fields situated in the west and northwest parts of the study area, where as Lower Goru sands are producing in Sara West, Mari Deep, Khipro, Miano, Kadanwari, Khairpur and Sawan fields situated in the east, central and western parts of study area.

Productive reservoirs in the Sembar-Goru/Ghazij Composite Total Petroleum System include the Cretaceous Sembar, Goru, and Pab Formations and the Eocene Sui and Ghazij Formations .The principal reservoirs are deltaic and shallow-marine sandstones in the lower part of the Goru in the Central Indus Basin.

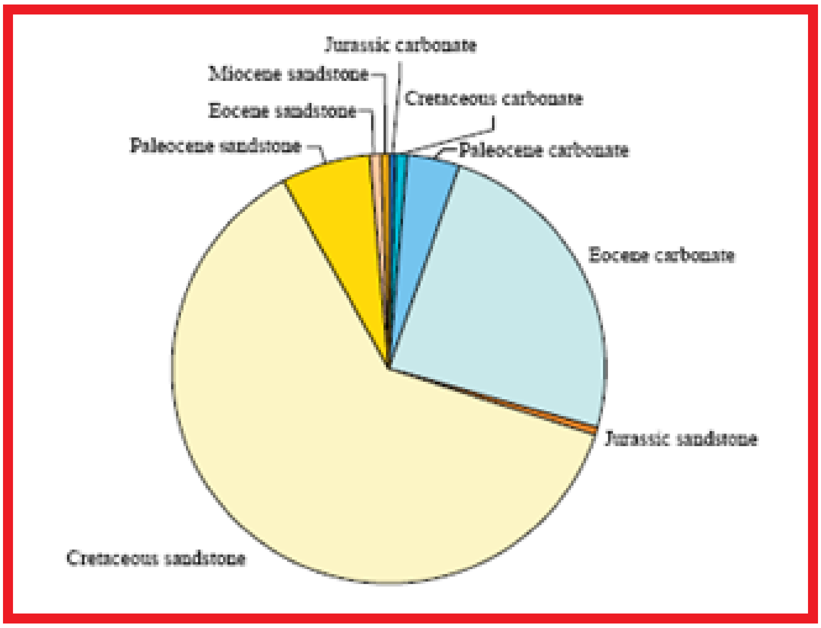


Fig. 3.1 : Plot showing lithologic and temporal numeric distribution of productive reservoirs in the Sembar-Goru/Ghazij Composite Total Petroleum System. (IHS Energy Group, 2001)

3.5 Seal Rock

Interbedded and overlying shale's of upper Goru (Goru sand), Sui Main limestone and The Ghazij shale can act as a cap rock for Sui Main Limestone and Sui Upper Limestone reservoirs.The known seals in the system are composed of shales that are interbedded with and overlying the reservoirs. In producing fields, thin shale beds of variable thickness are effective seals. Additional seals that may be effective include impermeable seals above truncation traps, faults, and updip facies changes (Quadri, 1986; Viqar-un-Nisa, 1986).

Sequences of Lower Goru

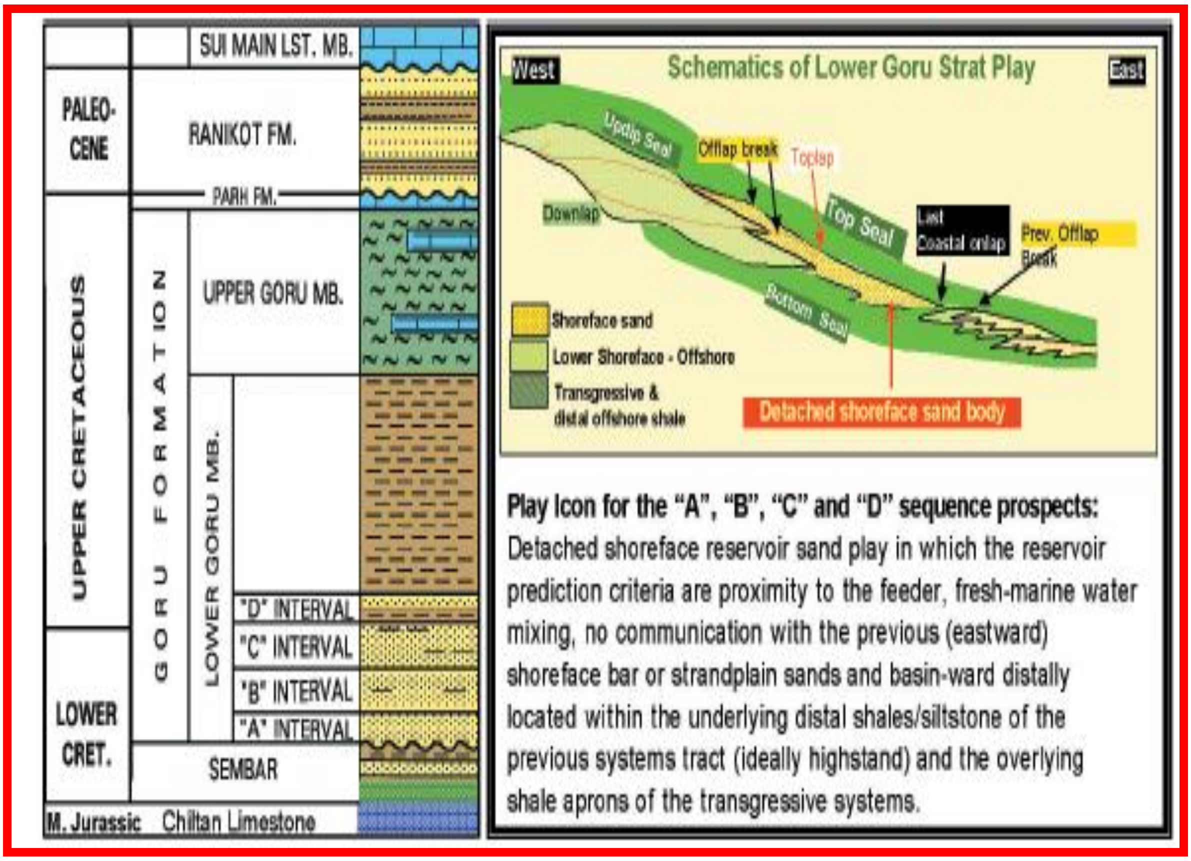


Fig. 3.2 (i) Stratigraphic column on the left showing position of the Lower Goru prospective sands within the regional stratigraphic framework. (ii) Play icon on the right showing how the prospects generally work in this study

CHAPTER #4

SEISMIC DATA ACQUISITION

4.1 Seismic data acquisition

The first step involved in seismic study of an area is the acquisition of seismic data. Acquisition of data means that the procedure through which the seismic reflection data is obtained. It is the very first step in the interpretation of seismic data. Seismic exploration is the primary method of exploring for hydrocarbon deposits, on land, under the sea and in the transition zone (the interface area between the sea and land). Although the technology of exploration activities has improved exponentially in the past 20 years, the basic principles for acquiring seismic data have remained the same.

Seismic data is of two types:

- **Seismic reflection data**
- **Seismic refraction data.**

However, seismic reflection data is used more frequently due to its wide application in the oil industry. Reflection refers to the seismic energy that returns from an interface of contrasting acoustic impedance, known as reflector. This energy is recorded at the surface by sensitive detectors which respond to the ground motion produced by the reflected energy in time from place to place, which is indicative of the shape of structural features and their locations in sub-surface. Therefore, reflection techniques are mainly used in oil industry to produce structural maps of such deep-seated conFigurations such as anticlines, faults and salt domes (Dobrin and Savit, 1988).

Seismic acquisition (Figure 4.1) is imperfect, as it transmits seismic signals into the subsurface and records them at discrete intervals .If the ideal acquisition were possible, there would be no need for processing.

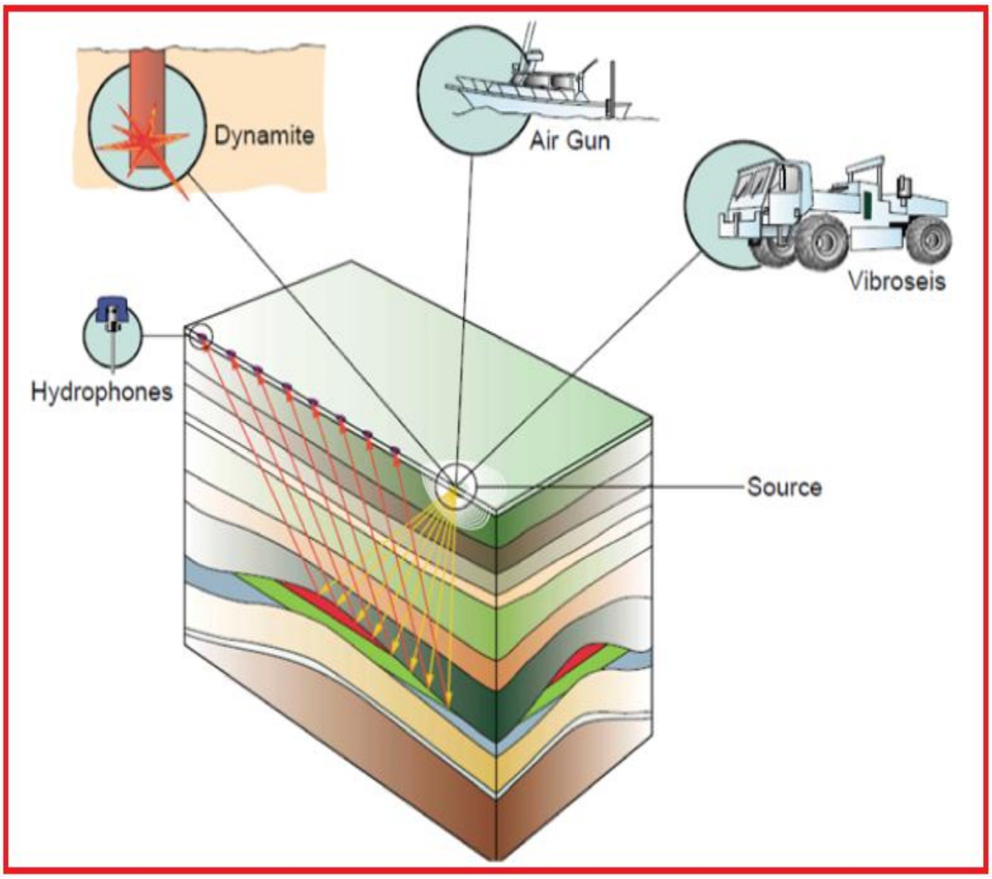


Fig. 4.1: Seismic Acquisition

Acquisition determines the ultimate achievable resolution and quality of data for interpretation. The selection of the survey design, equipment and the ground/sea conditions in the area of interest control:

- The frequencies in the data
- The wavelet
- Signal to noise
- Additional noise components

4.2 Basic principle of seismic data acquisition

In simple terms and for all of the exploration environments, the general principle is to send sound energy waves (using an energy source like dynamite or Vibroseis) into the Earth, where the different layers within the Earth's crust reflect back this energy. These reflected energy waves are recorded over a predetermined time period (called the record length) by using hydrophones in water and geophones on land. The reflected signals are output onto a storage medium, which is usually magnetic tape. The general principle is similar to recording voice data using a microphone onto a tape recorder for a set period of time. Once the data is recorded onto tape, it can then be processed using specialist software which will result in processed seismic profiles being produced. These profiles or data sets can then be interpreted for possible hydrocarbon reserves.

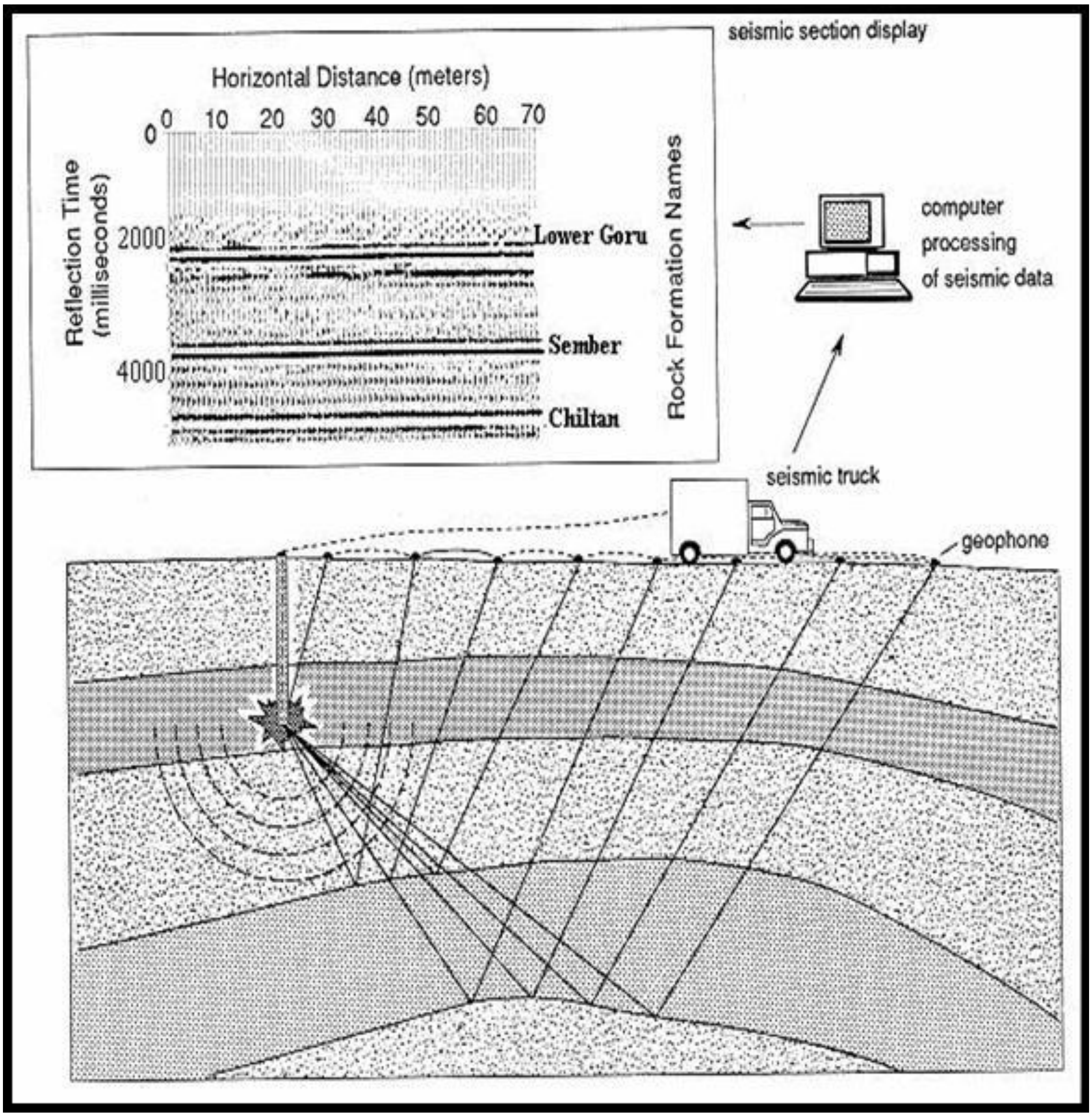


Fig. 4.2 Seismic data acquisition, Processing, followed by Interpretation (www.kgs.ku.edu/Publications/Oil/gifs/Fig21.gif

LINE NAME	P2291-19	P2291-14	P2291-41
LINE	STRIKE	DIP	DIP
LINE DIRECTION	WEST EAST	NORTH - SOUTH	NORTH - SOUTH
DATA RECORDED	15-24 OCT 1991	15-24 OCT 1991	15-24 OCT 1991
FOLD	3000%(nominal)	3000%(nominal)	3000%(nominal)
DATUM	MSL	MSL	MSL

Fig. 4.3 General information about seismic lines under study (adopted from seismic section

4.3 Energy sources

The most common method applied in generating seismic waves is exploding dynamite in short holes. There are however other methods which have been introduce as alternative seismic sources. Energy sources are categorized in two groups

4.3.1 Impulsive Energy Sources

4.3.2 Non-Impulsive Energy Source

4.3.1 Impulsive energy sources

Sources include dynamite, ammonium nitrate, which are available in different sizes. For most seismic surveying the explosive charge is detonated in a hole. The depth of this shot hole can range from few feet to hundreds depending on various circumstances. Explosives can be used for marine surveying but other more convenient devices are satisfactory for many purposes, one such device capable of producing strong impulses of energy is called as Air gun.

4.4.2 Non-impulsive energy sources

In the Vibroseis system a pad pressed firmly to the ground produces energy, which vibrates in a carefully controlled way. The pad, which is about one square meter, is attached beneath a truck by hydraulic jacks. Extending these jacks allows the weight of the truck to be used to press the pad to the ground. The vibration produce of varying frequencies called sweep signals. The vibration that varies from low frequency to higher and from higher frequency to lower is called upsweep and down sweep respectively. The typical sweep signal last for seven or more seconds and varies in frequencies between limits of about 10 and 80 Hz.

SOURCE TYPE	DYNAMITE
EXPLOSIVE TYPE	WAH NOBEL S-3
CHARGE SIZE	3 KG PER HOLE.
PATTERN	SINGLE HOLE
DEPTH	22m

Fig. 4.4 source parameters for seismic lines of study area

4.4 Receiver Array parameters

The receiver used to detect ground vibrations is called a geophone or a seismometer. It is used for seismic surveying on land and it can be operated on ocean floor if mounted in a suitable container. Most common type of geophone is moving coil geophone. It consists of a cylindrical coil that is suspended from a spring support in the field of permanent magnet that is attached to the instrument casing. The magnet has a cylindrical pole piece inside the coil and an annular pole pieces surrounding the coil.

Due to ground vibrations the coil starts too and fro motion generates the voltage across the terminal of the coil. The geophone is fixed by a spike base into soft ground or mounted firmly on hard ground.

GEOPHONE TYPE	SENSOR SM-4 10HZ
GEOPHONE WIDTH	16-20m
GEOPHONE SPACING	4.16m
ARRAY LENGTH	50m(nominal)
NEAR TRACE OFFSET	62.5 M
FAR TRACE OFFSET	3037.5 M

Fig 4.5 Receiver parameters for seismic lines of study area

4.5 Recording systems

There are two types of recording systems generally being used in seismic surveys.

4.5.1 Analogue recording system

4.5.2 Digital recording system

4.5.1 Analogue recording system

It is either the graphical representation of the variation in amplitude with respect to time of the seismic waves on paper called seismogram or on the magnetic tape.

4.5.2 Digital recording system

Geophones, placed at intervals, receive seismic waves. The system used to record the rate of change of amplitude of these waves in the form of numbers is called digital recording system. The digital data recorded on a tape is in the form of binary numbers.

INSTRUMENT TYPE	SERCEL SN348
TAPE FORMAT	SEG "B"6250 BP1
LOW CUT FILTER	12.5Hz
HIGH CUT FILTER	125Hz
RECORD LENGTH	5 sec
SAMPLE RATE	2 m sec

Fig. 4.6 Recording parameters for seismic lines of study area

4.6 Spreads

In seismic reflection surveys the arrangement of geophones that is used to record data is called spread. In seismic lines under study, 120 Trace Split spread has been used. Split spread means that the geophone groups are kept on for seismic signals, on both the sides of a source point. The near offset (distance from source to nearest group) is 125 meters and the far offset (distance from source to farthest group) is 3075 m.

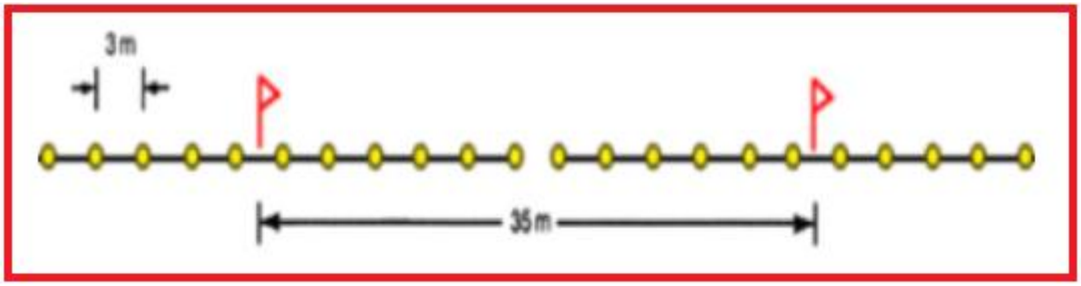


Fig. 4.7 Spread

CHAPTER #5

SEISMIC DATA PROCESSING

5.1 Seismic data processing

Data processing is a sequence of operations, which are carried out according to the predefined program to extract useful information from set of raw data.

During the last two decades the seismic prospecting for oil and gas has undergone a digital revolution due to the rapid advancement in the electronic computers. Seismic data processing has taken a new shape after the introduction of computers. The seismic data processing involves extensive computation for the detection of complex wave structure receives from deeper horizon of earth and then to extract valuable information regarding the subsurface lithology and physical properties of the rocks (Telford, 1976).

Seismic data are recorded in the field on magnetic tape. The objective of the processing is to convert the raw data on magnetic tape, into seismic section showing seismic reflectors which are the response of geological features such as folds, fault etc. Processing seismic data consist of applying a sequence of computer programs, each designed to achieve one step along the path from field tape to record section. The basic interest of a geophysicist is to improve signal to noise ratio in seismic data processing. Alteration of seismic data to suppress noise, enhance signal and migrate seismic events to the appropriate location in space (Sheriff, 1991).

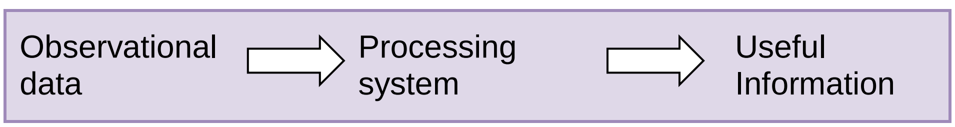
Processing steps typically include analysis of velocities and frequencies, static corrections, deconvolution, normal move out, dip move out, stacking, and migration, which can be performed before or after stacking. Seismic processing facilitates better interpretation because subsurface structures and reflection geometries are more apparent. Processing is usually done in SEG-Y format. Each individual processing contractor has its own particular packages of computer programs. Seismic processing facilitates better interpretation because subsurface structures and reflection geometries are more apparent (Sheriff, 1991)

Successful exploration and exploitation programs require the best possible "picture" of the subsurface. Seismic migration is one of the four basic steps that give us the best "picture". These four primary data processing steps are; in their usual order of application

- Demultiplexing
- Deconvolution
- Stacking
- Migration

5.2 Processing in general

Data processing is a sequence of operations, which are carried out according to the pre-defined program to extract useful information from a set of raw data as an input-output system (Al. Sadi, 1980). Processing may be schematically shown as.



The processing sequence followed during processing of seismic lines under study is displayed in Figure 5.1**.**

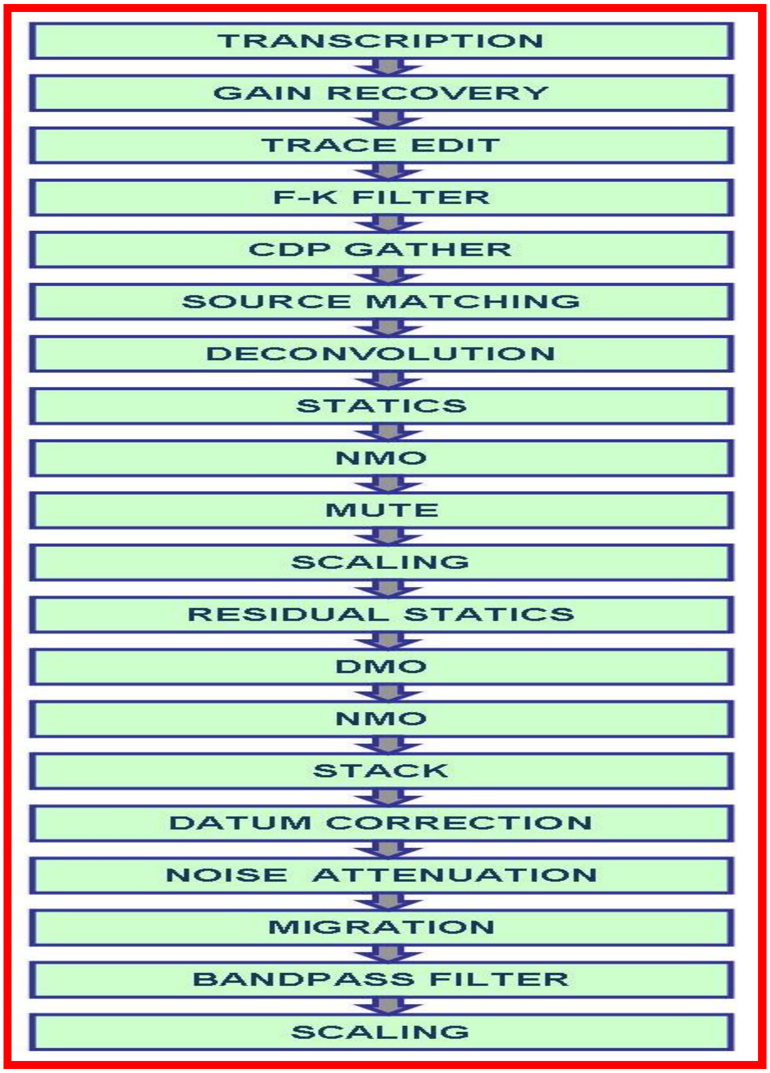


Fig. 5.1 Processing sequence followed in the processing of available seismic data (adopted from seismic section)

CHAPTER #6

SEISMIC DATA INTERPRETATION

6.1 Data interpretation

The word interpretation actually means the translation of seismic information into geological terms. The transformation of seismic reflection data into a structural picture is done by the application of corrections, migration, and time-depth conversion. The process of geological interpretation needs the greatest possible coordination between geology and geophysics. For a good and reliable interpretation of Seismic Reflection data, one must have a good knowledge of the geology of the area from where the data have been acquired.

The basis for seismic interpretation is the association of specific reflections with specific acoustic impedance contrasts or series of contrasts in the earth. The impedance contrasts are usually linked to given Formation or bed boundaries, usually through well control (such as velocity surveys, sonic information, or VSP) but occasionally by outcrop. Lateral continuity in reflection is attributed to lateral continuity in the bed or physical cause of the reflection.

Interpretation is carried out by combined teams of structural geologists, stratigraphers, and geophysicists. They try to determine the geological structures, to identify the Formations traversed by seismic waves, to obtain information about the petrophysical parameters, porosity, fracturation, facies variations, and the presence of hydrocarbons. Interpretation relies on seismic stratigraphy, the reconnaissance of deposition environments and sedimentary bodies, and seismic lithology, the determination of lithological and petrophysical parameters from the analysis of seismic trace (Michel Lavergne, 1989).

Seismic data have been interpreted in two modes, with gradations between the modes. The first is in areas of substantial well control, in which the well information is first tied to the seismic information, and the seismic then supplies the continuity between the wells for the zones of interest. The second mode is in areas of no well control ("frontier areas"), in which the seismic data provide both definition of structure and estimates of depositional environments. The more information incorporated into the interpretation, the better the interpretation becomes. Integration of seismic data with the geological information, whether from satellite, surface, or subsurface sources (e.g., fault traces or geologic contacts) involves identifying reflections and making ties to wells or surface features. The extent to which .it can be done depends on the amount of geologic information available (Dobrin, 1988).

A sequence of sedimentary rocks is grouped into units called Formations. These Formations can be described in terms of age, thickness and lithology of the consistent layers. For this purpose, seismic surveys are planned so that a profile passes close to a well that penetrates the Formations of interest. Seismic data are then correlated with well data and already known geology of the area to construct a subsurface geological model. If no wells are situated along the seismic profile, then it is necessary to Figure out what Formation might be present from geologic maps and more distant wells (Robins on & Coruh, 1988).

6.2 Methods of interpretation of seismic data

There are two main approaches for the interpretation of the seismic section.

6.2.1 Structural analysis.

6.2.2 Stratigraphic analysis.

6.2.1 Structural analysis

These are the features that developed as a result of structural deformation. Most structural interpretation use two way reflection time rather depth and time structural maps are constructed to display the geometry of selected events. Discontinuous reflections clearly indicate parts and undulating reflections reveals folded beds. Similarly diffraction is indication of faults.

In structural analysis the main objective is to search out the structural traps containing hydrocarbons. In such analysis interpretation usually take place against the background of the continuing exploration activity and associated increase in amount of the information referred to the subsurface geology.

6.2.2 Stratigraphic analysis

Seismic stratigraphy is used to find out the depressional process and environmental settings, because genetically related sedimentary sequence normally consists of concordant strata that shows discordance with sequence above and below it. It also helps to identify Formations, stratigraphic traps and unconformity. The stratigraphic traps can result from the features associated with erosional truncation, pinch out, reefs etc.

6.3 Practical points in seismic interpretation

The seismic reflection data are available as seismic reflection sections from a grid of intersecting seismic lines (Figure 19). The subject area comprise of strike line and dip lines.

P2291-OMV-19 is the strike line of the seismic section and its direction is NE-SW.

P2291-OMV-14 and P2291-OMV-41 are the dip lines of the seismic section and their direction is N-S. The base map of my study area is given below

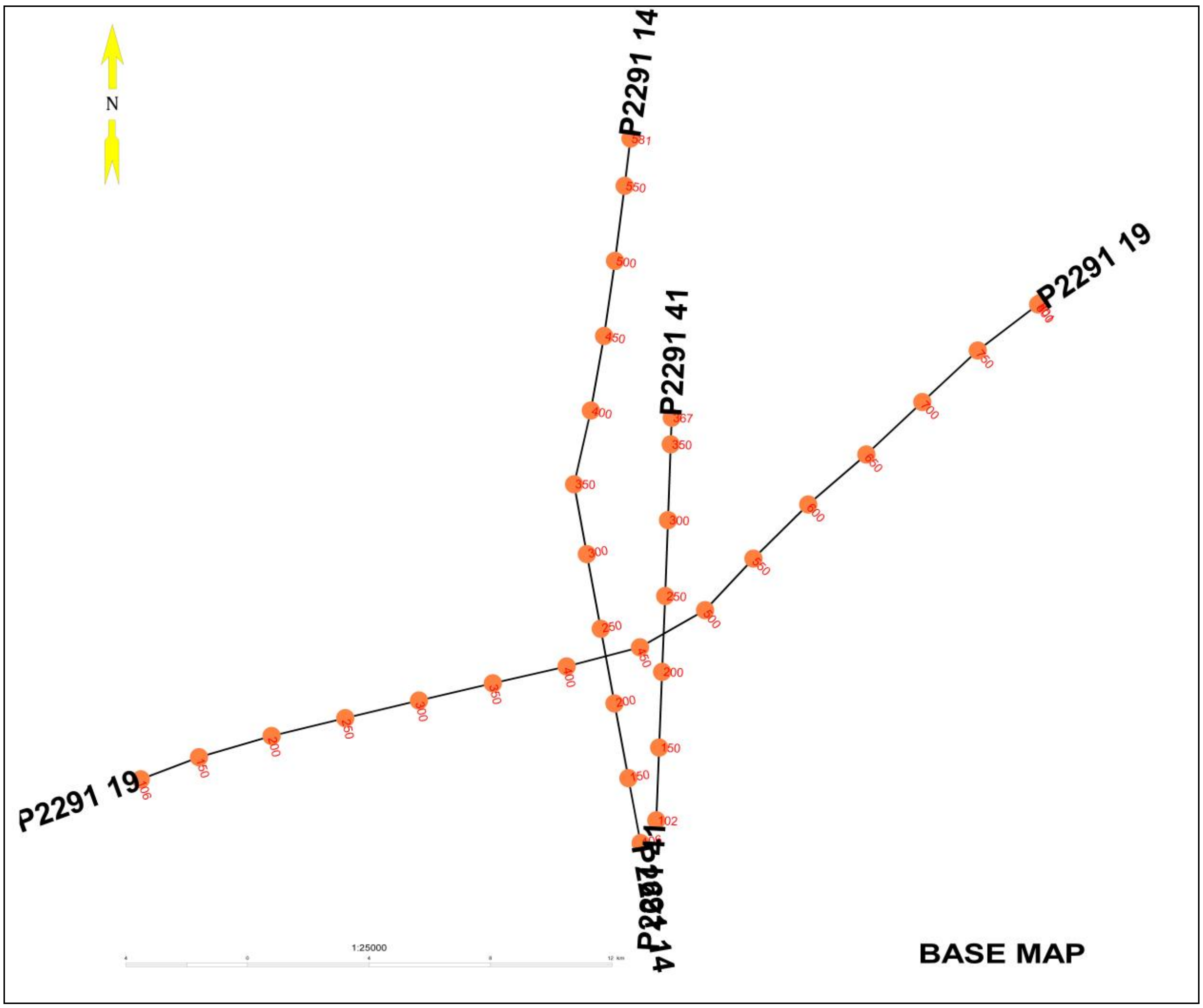


Fig. 6. 1 Base map showing seismic lines of study area

6.4 Picking and following a reflection

The best way to get the interpretation started is to pick a good shallow reflection and follow this in the area, if possible. The same is then done for the next deeper reflection, then the next deeper reflection etc. the general principle underlain this is that shallower reflections are usually less affected by tectonic features (such as faults) and are less distorted than the deeper ones.

A reflection can be extended over an area by several methods e.g. Intersecting seismic lines enables one to continue a reflection from one section to another through the intersection. If lines do not intersect some of the lines may lie close to each other, by comparing the two lines it is often possible to correlate the reflection being followed with a reflection on the other section.

In my seismic section first I pick the reflections of strike line and then I tie the reflections of strike line with the dip lines and by this way I pick my all reflection of seismic lines. The Figure below shows the reflections and faults of line 19 of my seismic section.

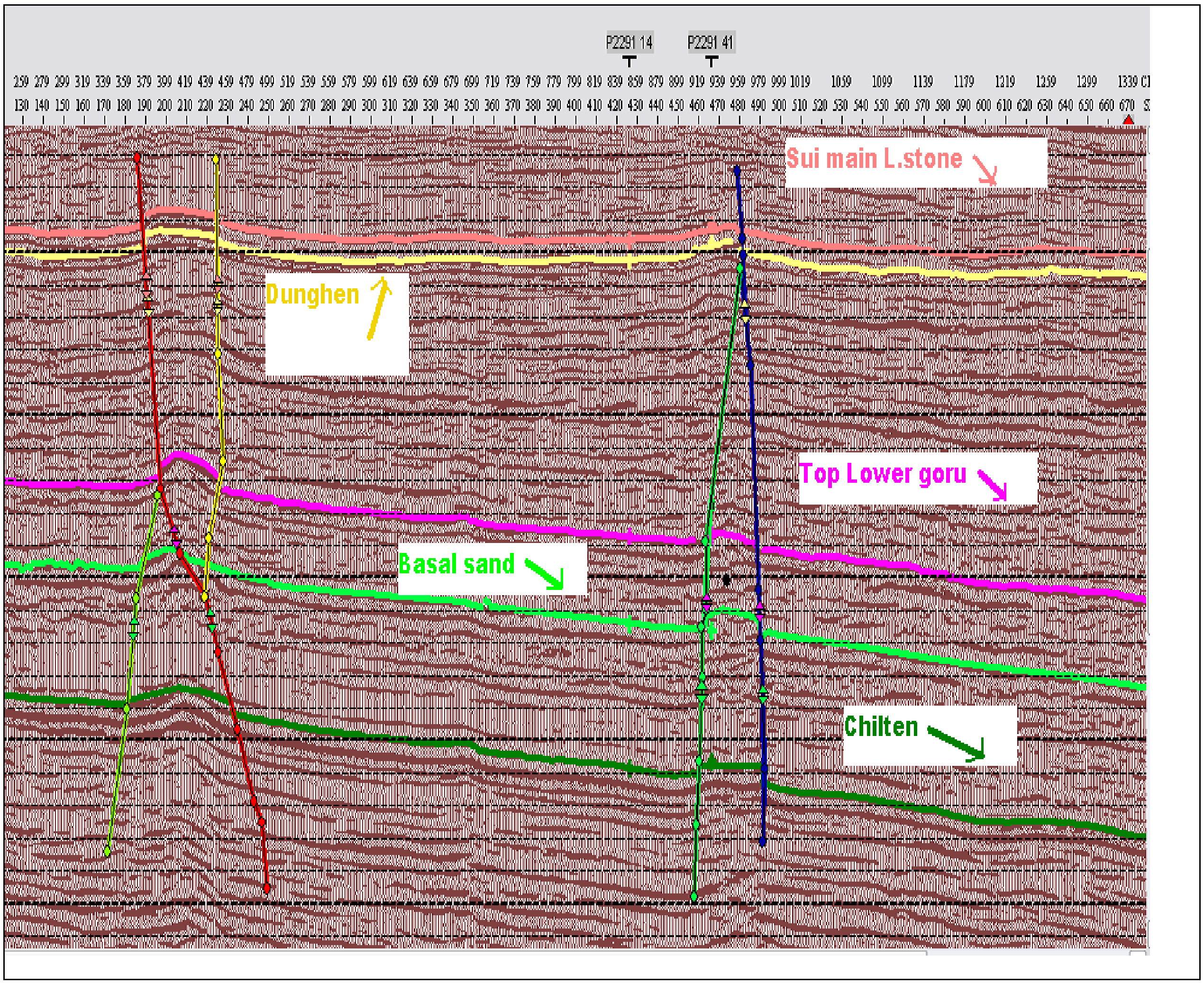


Fig. 6.2 faults and horizons of line 19 of seismic section

6.5 Faults identification

The detection of the fault on the seismic section can be quite easy under favorable circumstances. Often however, the indications are not very clear and the identification and the delineation of such faults can be quite challenging. In our area we observed normal faults. The following are the main identifications of fault in the seismic section. Figure 9.3 shows the seismic section in which faults are marked.

- By changes in the slope of the reflections.
- By interruption in the reflections.
- By shadow zone with contorted or absent reflections underneath the fault plane.
- By the presence of diffraction tails.

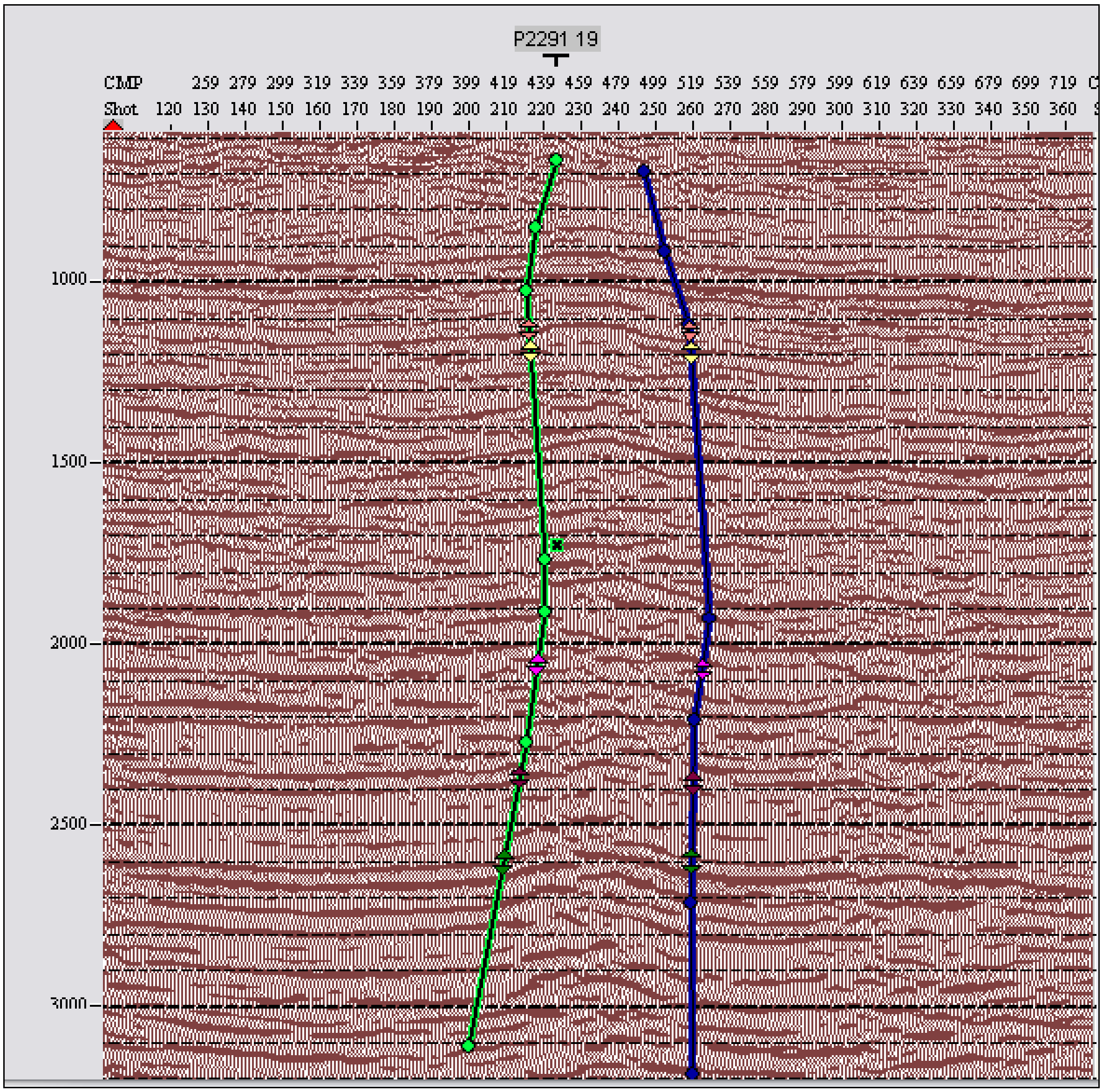


Fig. 6.3 faults marked on line 41

6.6 Time, Faults and Horizons identification on dip and strike lines of seismic section.

The Figures below shows the time section, faults and horizons of lines of my study area.

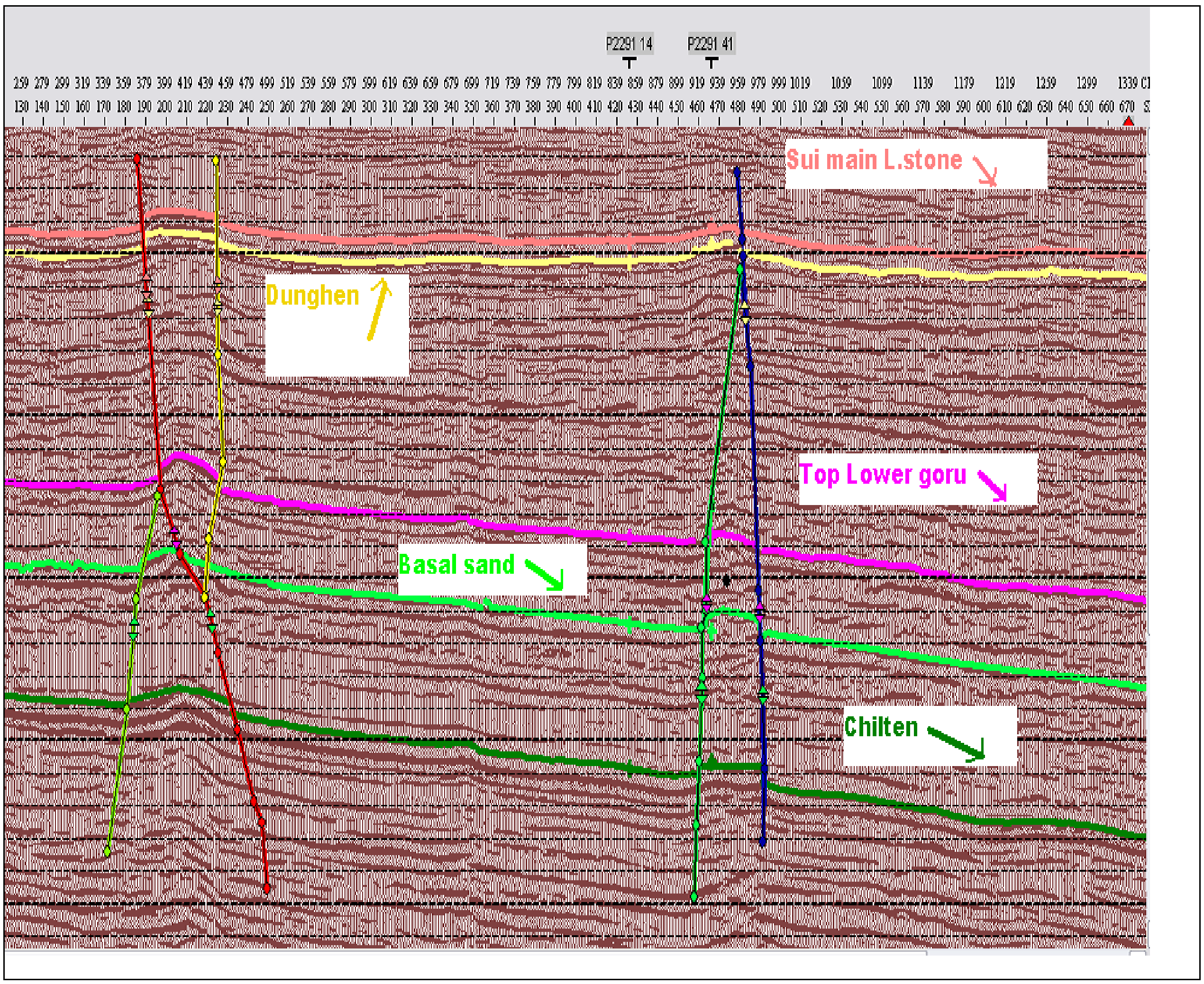


Fig. 6.4 faults and horizons of line 19

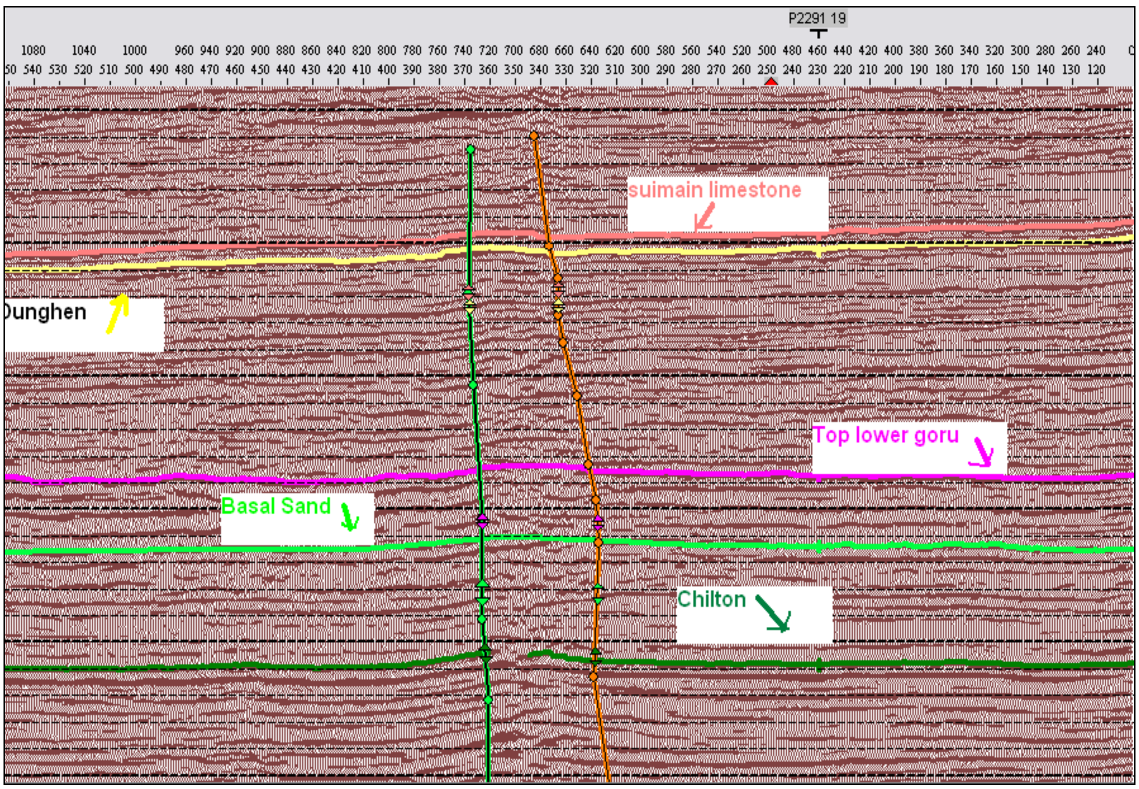


Fig. 6.5 faults and horizons of line 14

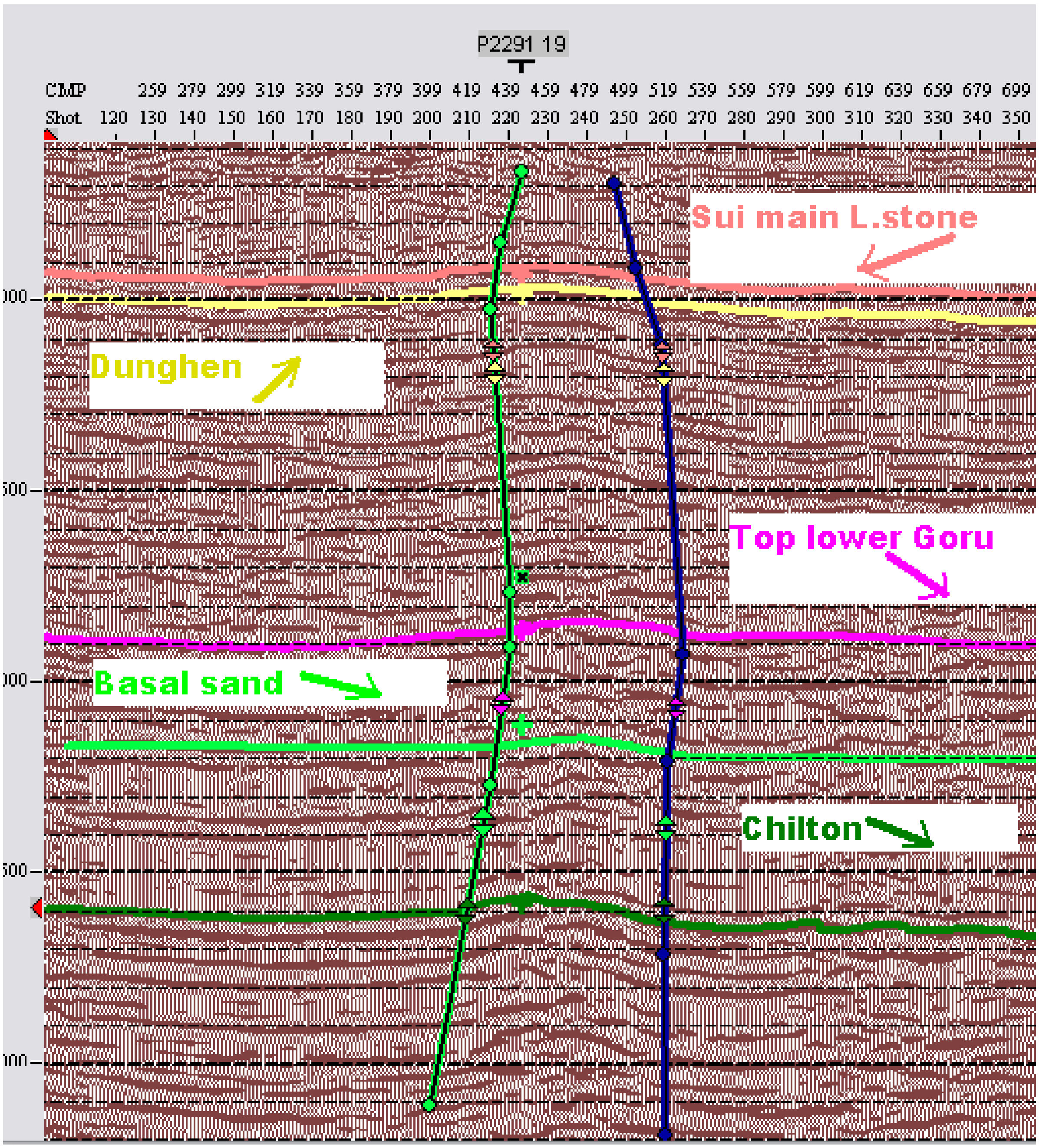


Fig. 6.6 faults and horizons of line 41

6.7 TWO WAY TIME (TWT) CONTOUR MAPS

Contour map is that map which is made up of contour lines, and the contour lines are those lines which join points of equal values. So in TWT contour maps, the map is made up of the values of time. This value of time is the time taken by the seismic waves to go into the subsurface, hit an interface, and come back to the surface. The TWT map is made for any Formation of interest, so this map shows the position of that Formation in time. The highs on the map show the areas which are at shallow level, and they have low values. The lows or depressions show the areas which are at a deeper level, and they have high values. In this dissertation, the TWT Contour maps of the five horizons R1,R2,R3,R4 and R5 are made, the maps also show the seismic lines. For example, when looking for an appropriate position to drill for a well, the closure provided by the contours is given prime importance. As shown in Figures.

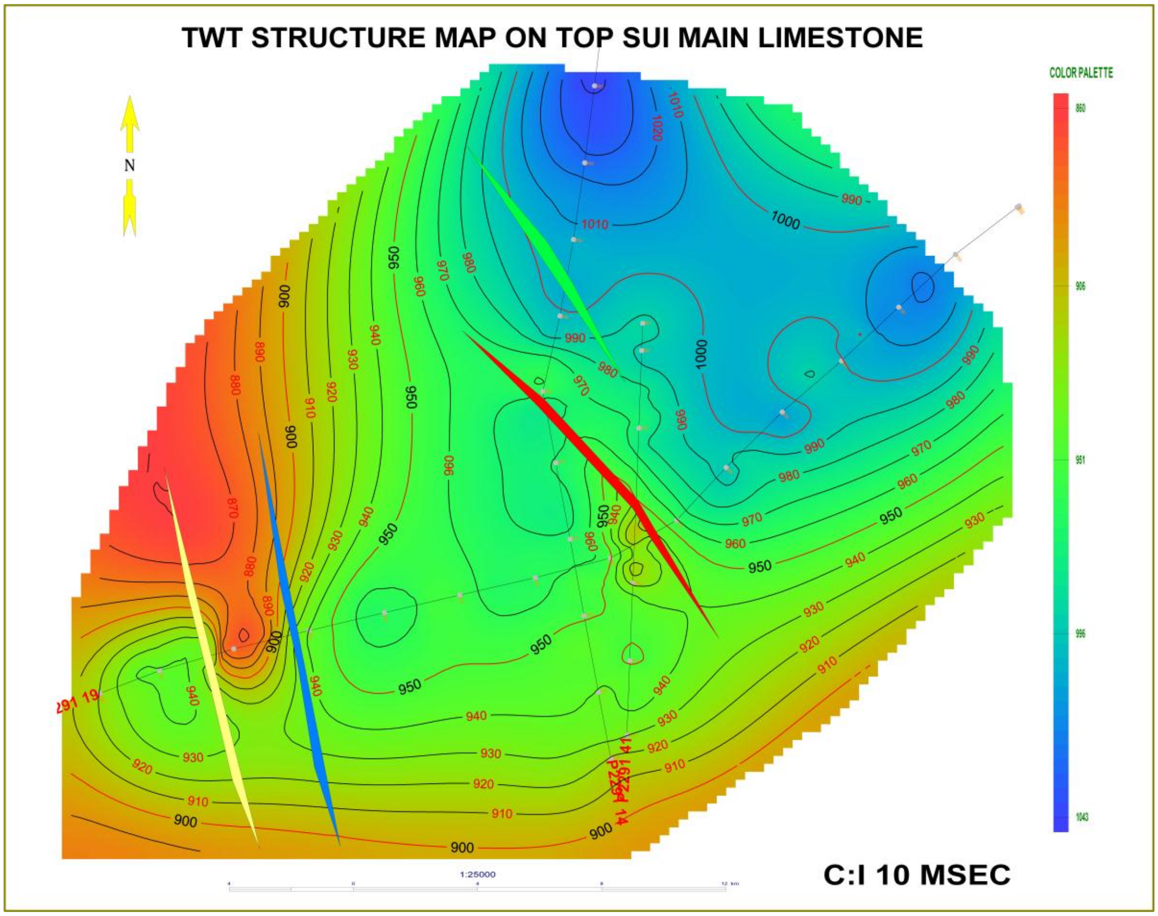


Fig. 6.7 TWT contour map of R1

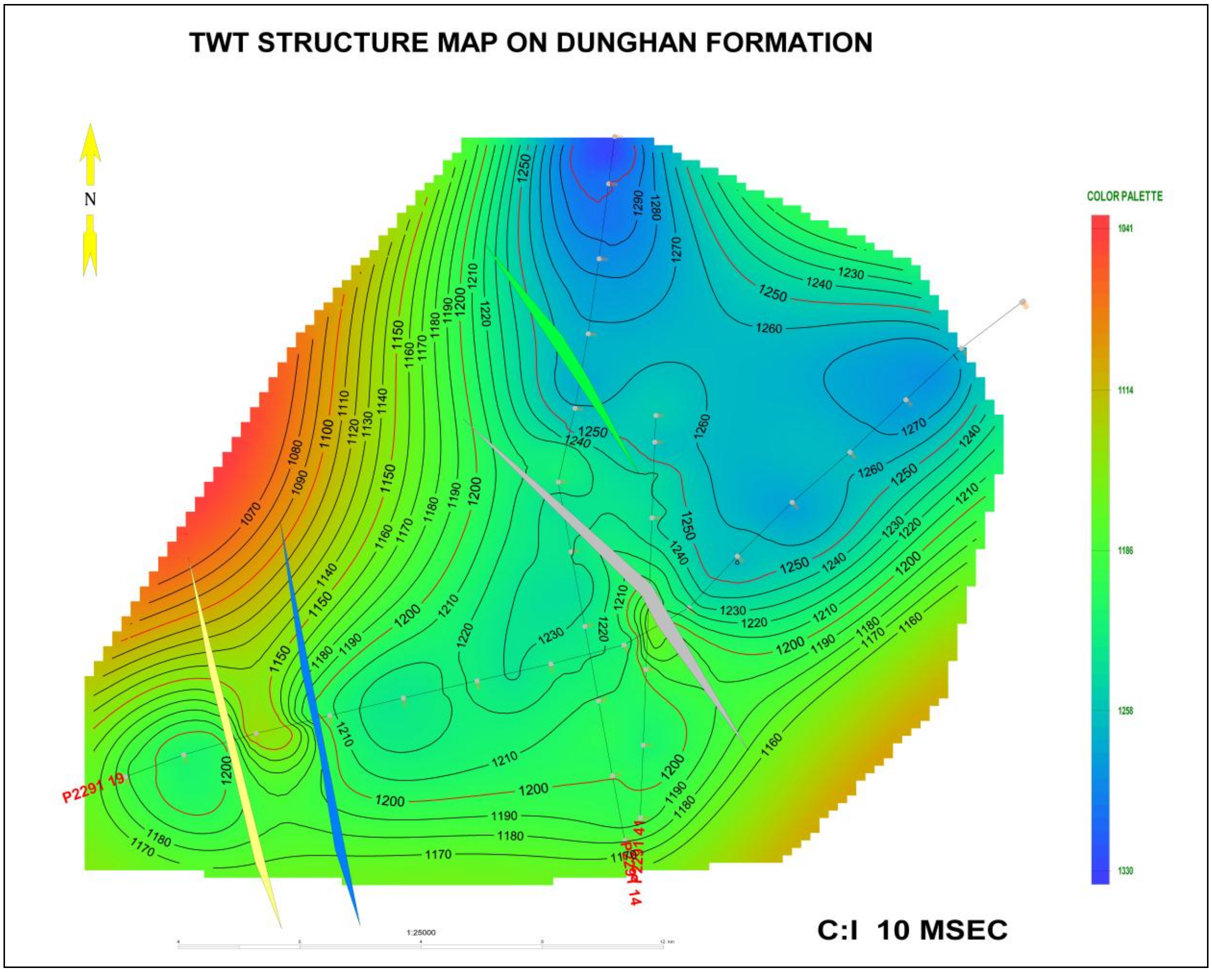


Fig. 6.8 TWT contour map of R2

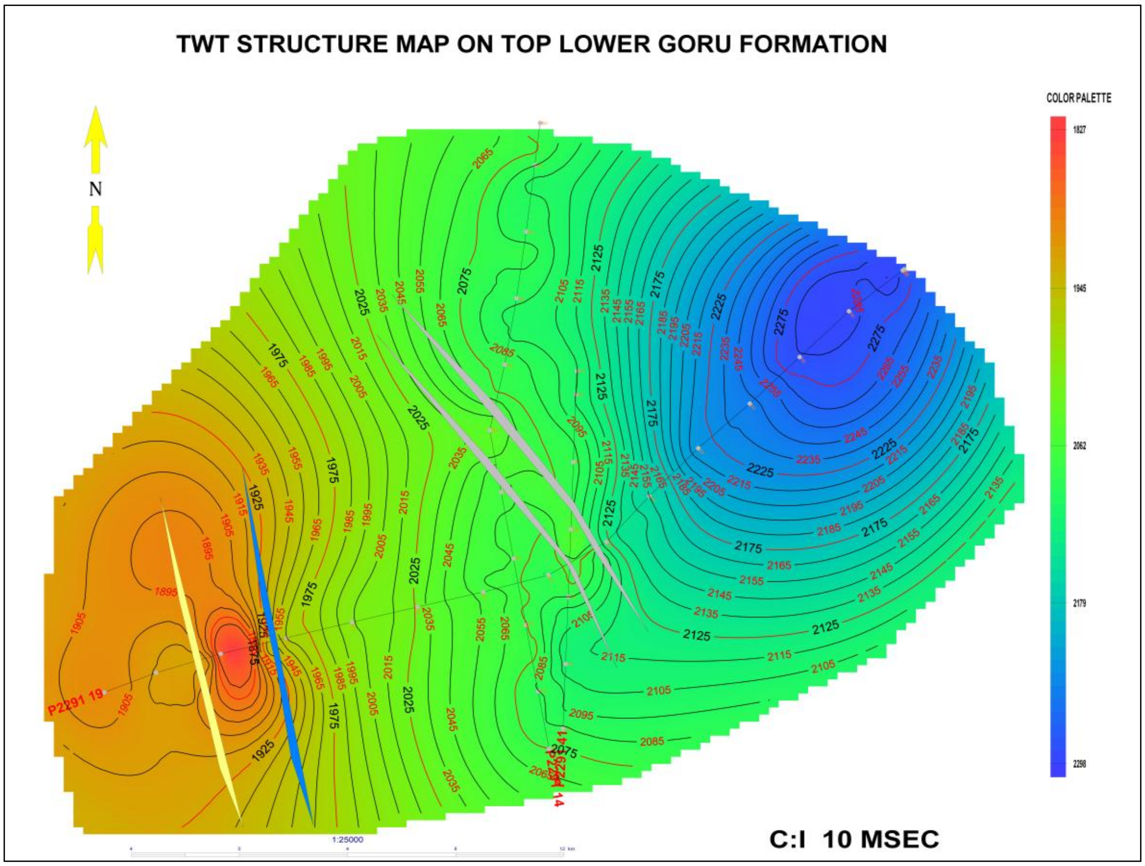


Fig. 6.9 TWT contour map of R3

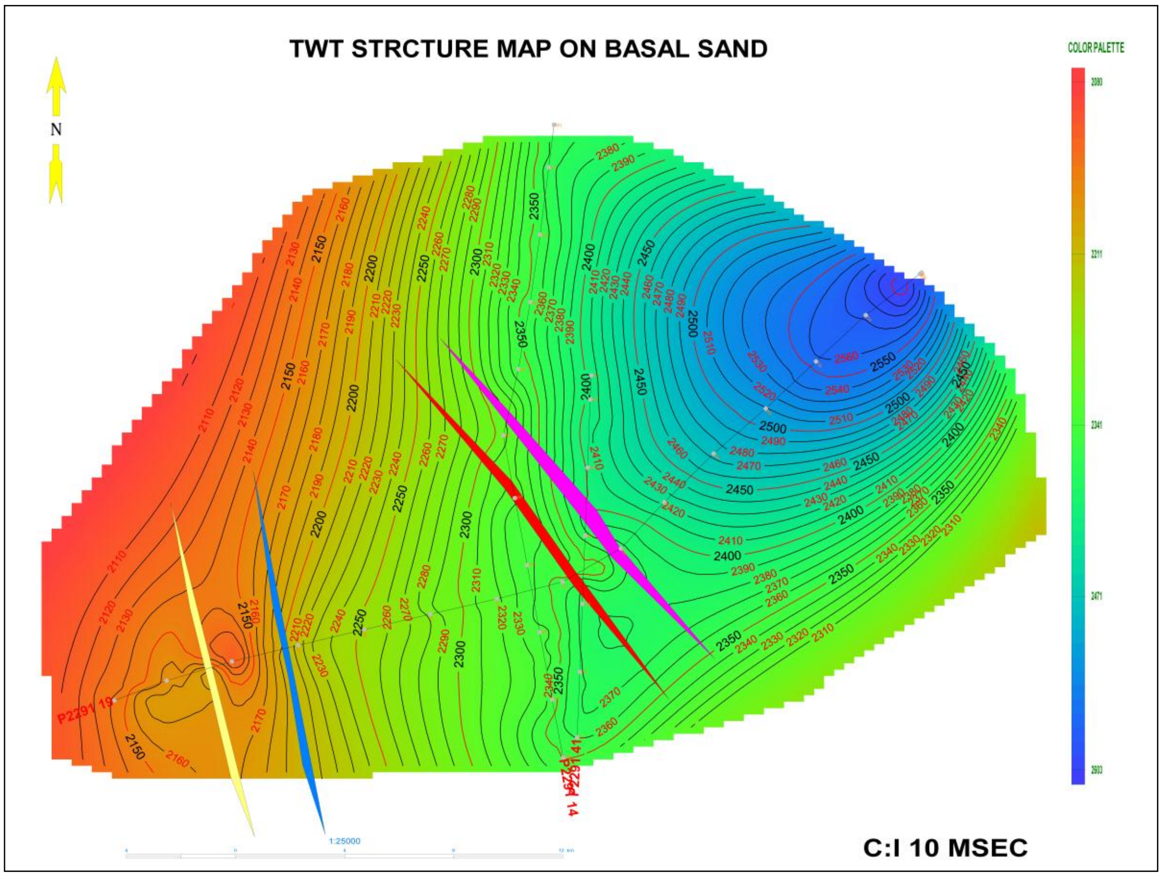


Fig. 6.10 TWT contour map of R4

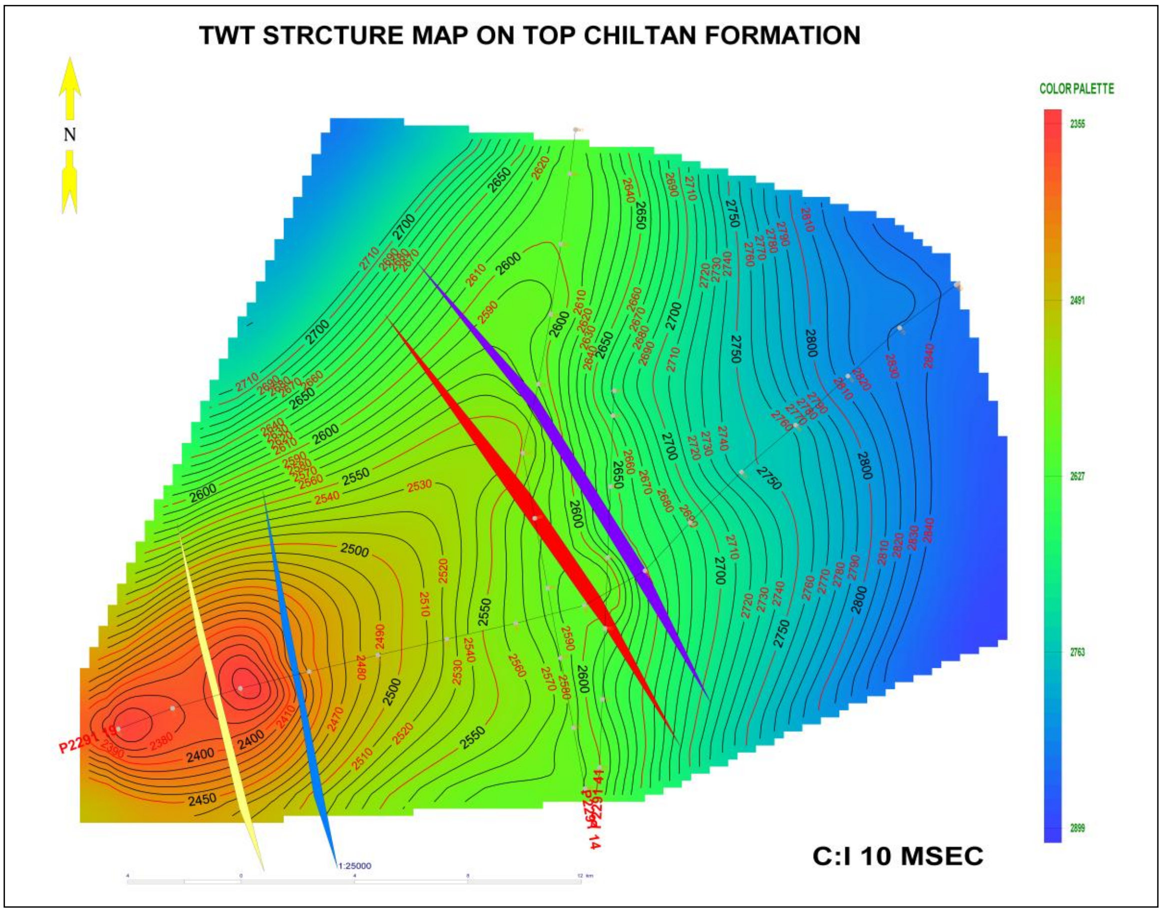


Fig. 6.11 TWT contour map of R5

6.8 Depth contour maps

The depth contour maps are made by joining the points of equal depth values. The depth values are the calculated depth values in which a particular Formation is present in the subsurface. In this dissertation, the depth values were calculated by firstly dividing the TWT by 2000 and then multiplying this by well velocity. This well velocity is the velocity with which the seismic waves travel in that particular Formation. The depth maps are more reliable when giving the well position because it truly gives the position of a point in that Formation. This is because the velocity factor is also involved. The depth maps were of the same Formations for which the TWT contour maps were made.

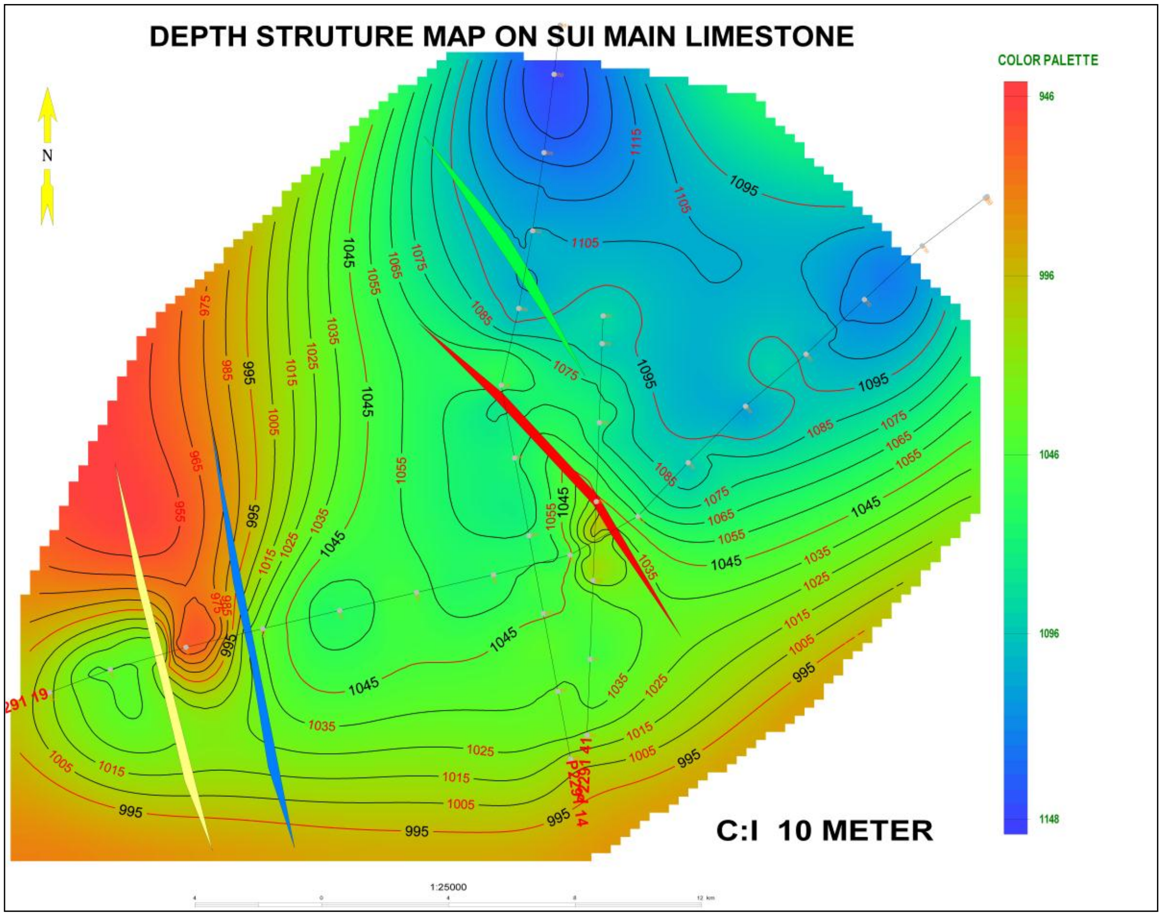


Fig. 6.12 Depth contour map of R1

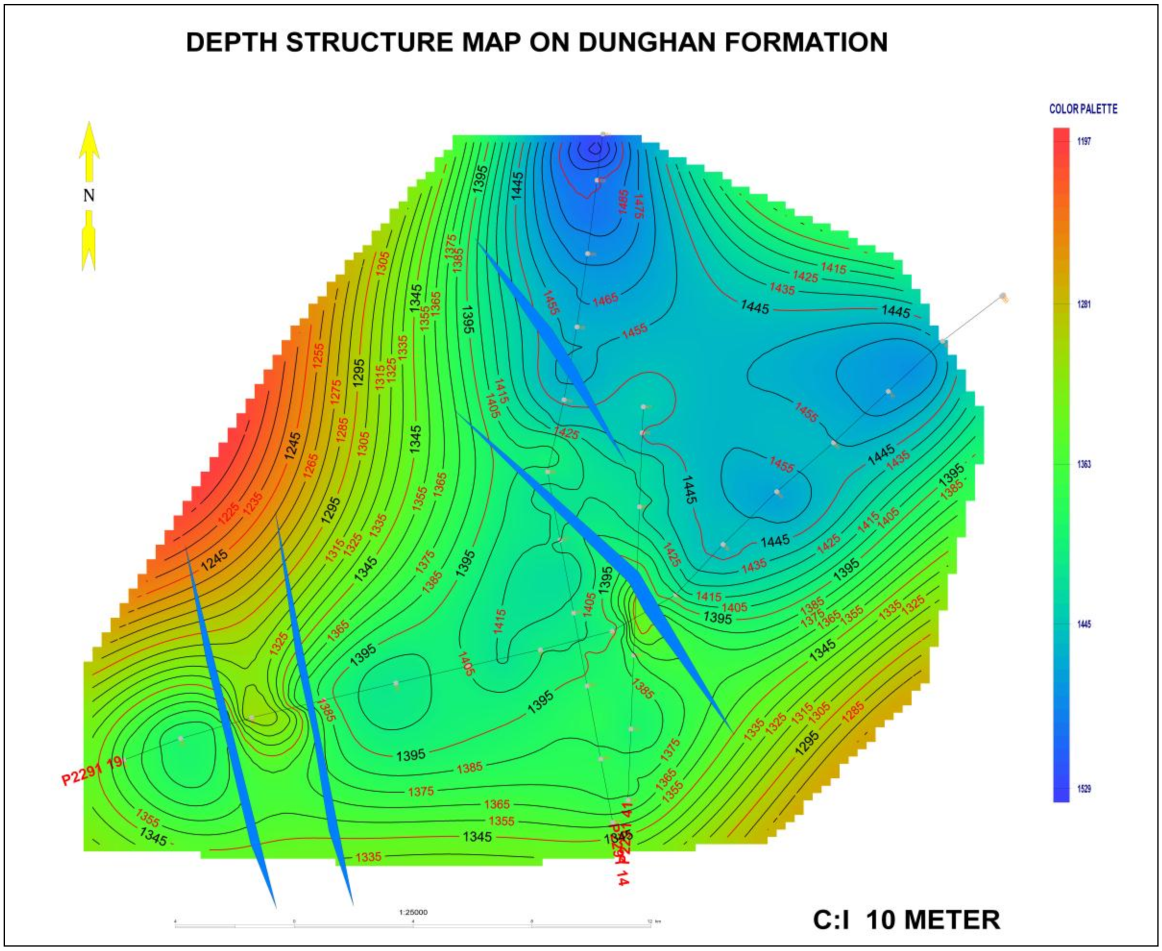


Fig. 6.13 Depth contour map of R2

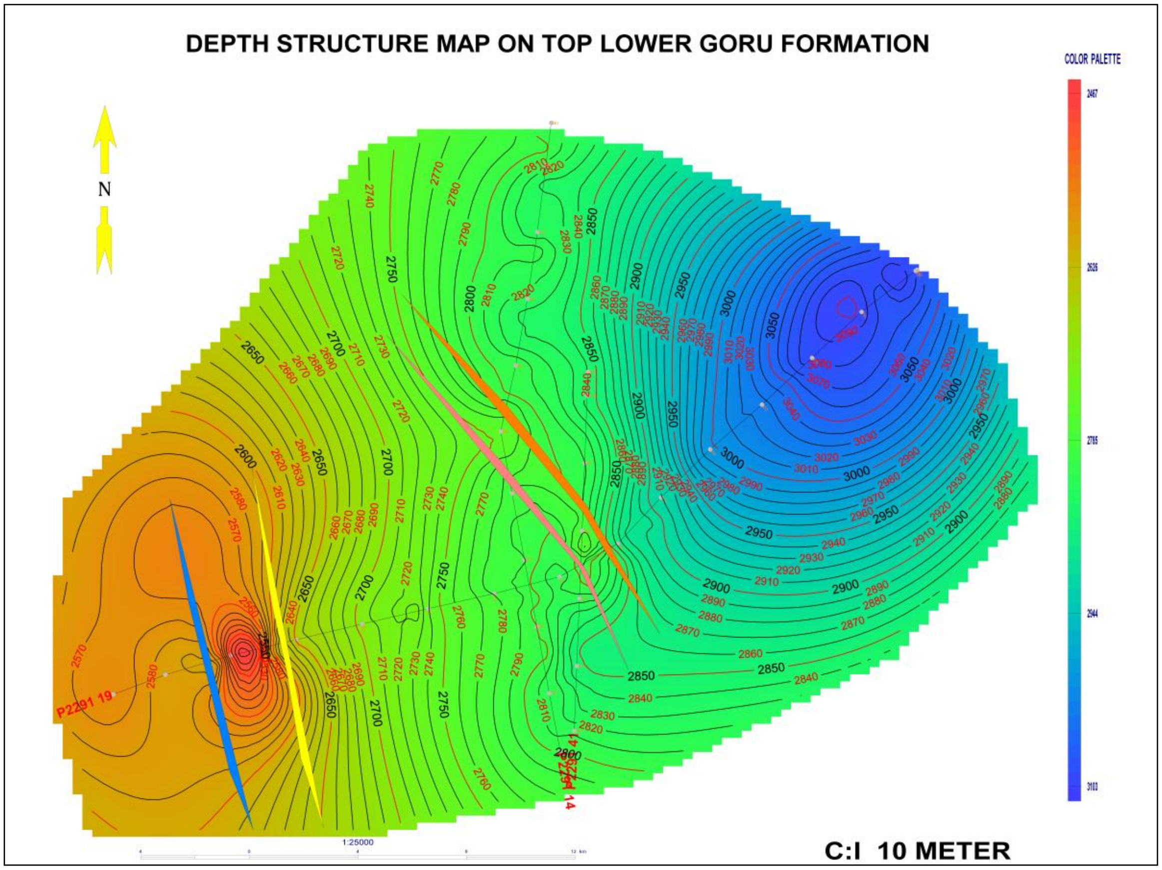


Fig. 6.14 Depth contour map of R3

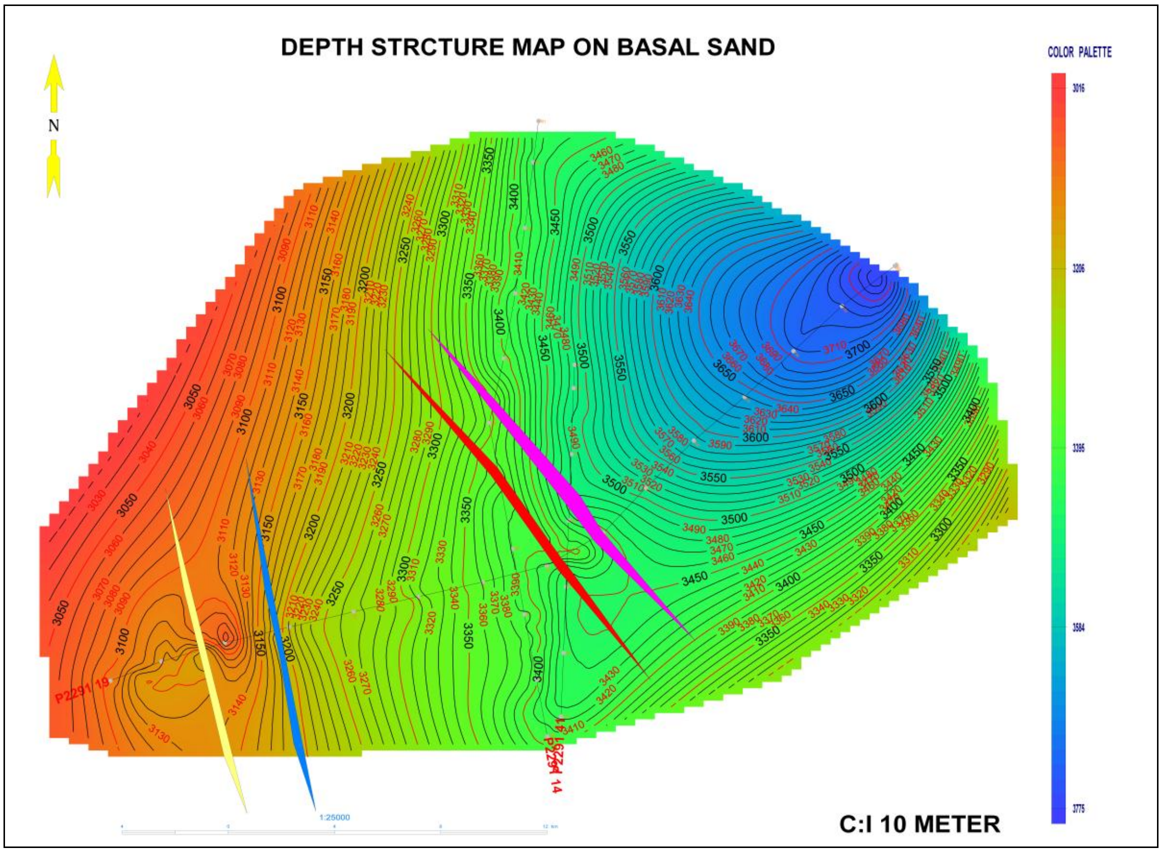


Fig. 6.15 Depth contour map of R4

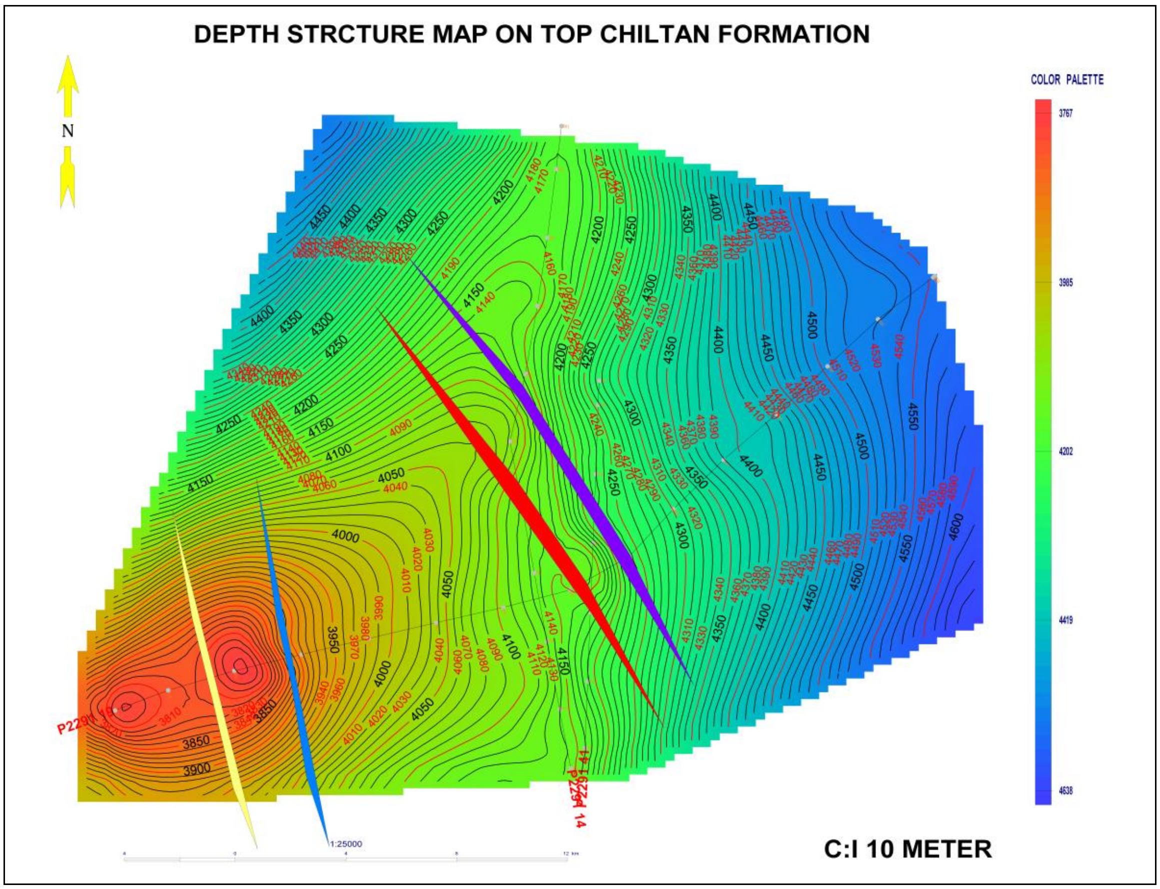


Fig. 6.16 Depth contour map of R5

7 CONCLUSIONS

- Seismic Lines P2291-OMV_19, P2291-OMV_14 and P2291-OMV_41 were provided by the DGPC to evaluate the project area, Sukkur (Sindh Province). After the interpretation of the given seismic sections, following conclusions are made:
- The interpretation is mainly done on the basis of reflection of different interfaces, stratigraphy of the area and the surrounding wells.
- The Project Area is under extensional regime, so normal faulting is dominated throughout the area.
- There were no prominent structural traps identified due to less seismic control. The seismic sections show a thick sedimentary cover, as basement is not present within the 5 second acquires data.
- Correlation of horizons R1, R2, R3, R4 and R5 and are Sui main limestone,Dunghen Formation, Top lower Goru Formation, Basal sand and Chilton Formation respectively obtained from Hassan well # 2.
- All the horizons show very slight undulations of deposition, i.e. showing approximately flat trend throughout the seismic section, which reflects that the Project Area was and is still under a low tectonic activity. Reason may be the fact that this area is located far-off from the collisional belts present in the North and the Northwest part of the country.

8. RECOMMENDATIONS

- To mark proper location to drill a Well and clearer picture of the Area more seismic lines are recommended.
- From the known stratigraphy, hydrocarbon plays and successes in the Area, it is recommended that the area can be a better hydrocarbon prospect zone; the common traps that could be found are the stratigraphic traps.
- From the interpretation of the seismic profile and studying geology of the Area, it is needed that more extensive and high resolution seismic

acquisition and processing are needed in the area to target further prospects.

9. REFRENCES

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