SUBSURFACE STUDIES OF MISSAKASWAL AREA USING 2D SEISMIC AND WELL DATA

BY

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PAKISTAN

“PAY THANKS TO ALLAH EVERY MOMENT AND GO TO EXPLORE THE HIDDEN TREASURES, ITS ALL FOR YOUR BENEFIT”

(AL-QURAN).

CERTIFICATE

This dissertation submitted by **WALEED IQBAL** S/O **BAKHT RAHMAN** is accepted in its present form by the Department of Earth Sciences, Quaid-i-Azam University Islamabad as satisfying the requirement for the award of BS degree in Geophysics.

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EXTERNAL EXAMINER

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ACKNOLEDGEMENT

In the name of Allah, the most Beneficent, the most Merciful. All praises to Almighty Allah, the creator of universe. I bear witness that there is no God but Allah, and Holy Prophet Hazrat Muhammad (P.B.U.H) is the last messenger of Allah, whose life is a perfect model for the whole mankind till the Day of Judgment. Allah blessed me with knowledge related to Earth. Without the blessing of Allah, I could not be able to complete my work as well as to be at such a place.

I am especially indebted to my dissertation supervisor Dr. Mumtaz Muhammad Shah for giving me an initiative to this study. His inspiring guidance, dynamic supervision and constructive criticism, helped me to complete this work in time. I pay my thanks to whole faculty of department of Earth Sciences especially the teachers and senior students of Department of Earth Sciences, their valuable knowledge, assistance, cooperation and guidance enabled me to take initiative, develop and furnishing my academic carrier. I am thankful to all my friends, my class fellows and senior students of Department of Earth Sciences, for giving their kind support during my dissertation work. I am also thankful to my parents, and family members for giving me all kind of support throughout my academic carrier.

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ABSTRACT

Two dimensional seismic interpretation has been carried out in Missakeswal area located in Chakwal district of Punjab province, Pakistan to reveal the subsurface geology. The data used for this study was provided by department of Earth Sciences, the main purpose of this dissertation is the seismic structural interpretation of the Missa Kaswal area in order to demarcate the probable zone for the accumulation of hydrocarbons. Seismic structural interpretation includes marking of reflector with the help of synthetic seismogram, fault picking, generation of polygon and time and depth contour map. To complete this dissertation SMT Kingdom 8.8 were used. The study area is located in Potwar Basin, pop-up anticline is major structure. Five seismic lines GO-994-GNA-09, 994-GNA-10,994-GNA-15,994-GNA-16,994-GNA-19,994-GNA-08 and Qazian Well-01 are used.

For the interpretation of the seismic lines, three reflectors are marked by correlating synthetic seismogram on seismic section.

Prospect evaluation (including gridding, Time and Depth contouring and identification of structural traps) has been carried out using Kingdom suit of Software. Structural interpretation has identified pop-up and snaked head structures favorable for hydrocarbon accumulation and is marked on seismic sections and time contour maps. These structures have been marked at Chorgali, Sakesar and Nammal formations of Eocene level, which are acting as reservoir rocks in the study area. The horizons are identified and named on the basis of well and generalized stratigraphic data.

Waleed Iqbal

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Table of Contents

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

1. Introduction

Qazian/Missa Kiswal oil field is located at 33° 11' 19" N 73° 21' 20" E and at a distance of about 60 kms in the south east of Islamabad. The field was discovered in june 1991 and came on a regular production from December 1992.Stratigraphically, it lies in the Upper Indus which is characterized by large numbers of thrust and normal faults producing asymmetrical structures (anticlines/ synclines).

The following figure shows the Missa Kaswal area located in upper Indus basin.

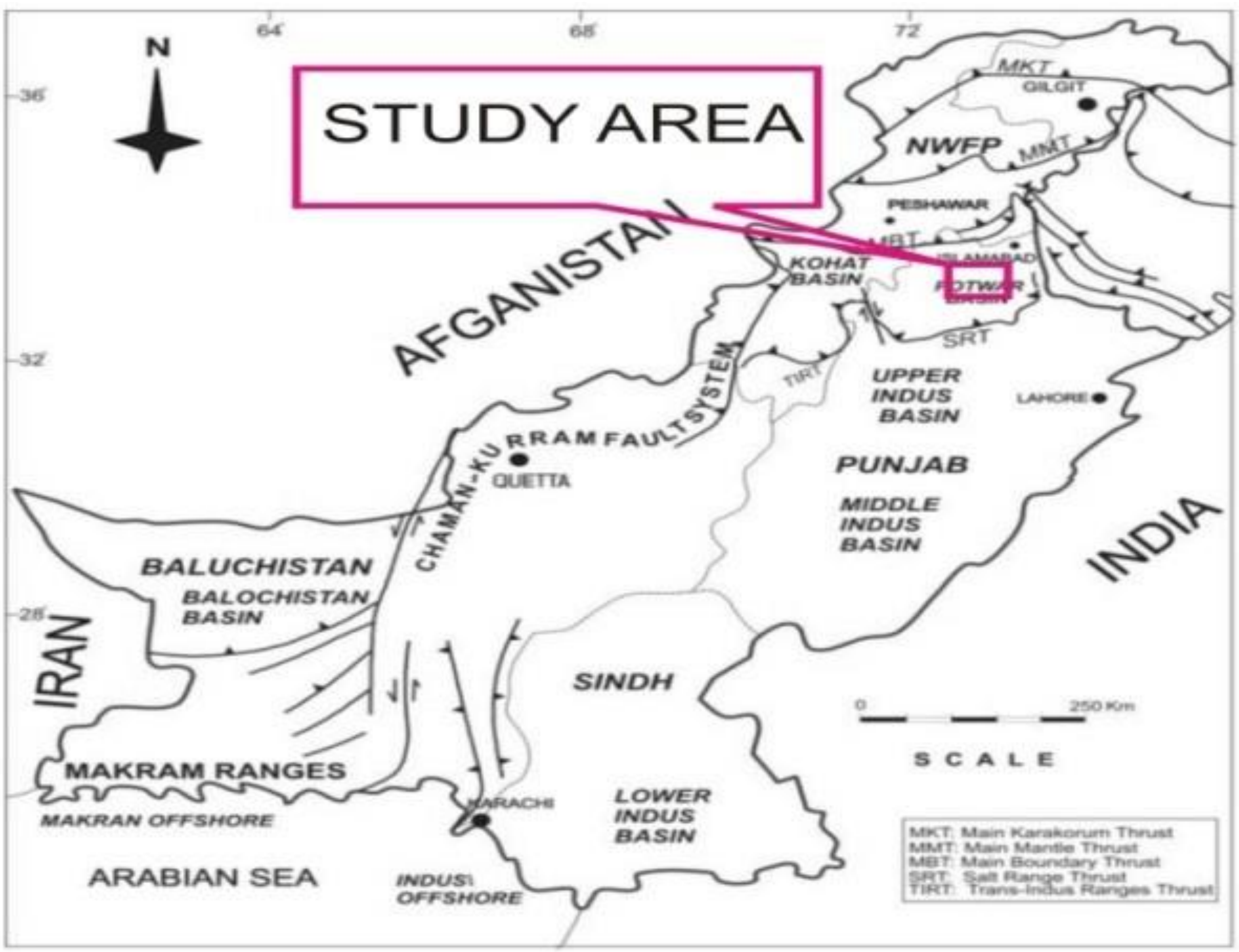

Figure1.1 Qazian/Missa Kaswal Field

Qazian X-01 is a shallow well with total depth of 2457 meters. Chorgali and sakesar of Eocene age were the primery target of drilling.

1.1 Seismic Data Detail

Five seismic lines were selected for study the area. The data was acquired by OGDCL in Sep 1999. Table 1.1 shows the acquired seismic lines.

Line Name	**Line Type**	**Line Orientation**
GO-994-GNA-09	Dip Line	NW- SE
GO-994-GNA-10	Dip Line	NW- SE
GO-994-GNA-15	Dip Line	NW- SE
GO-994-GNA-16	Dip Line	NW- SE
GO-994-GNA-08	Strike Line	NE – SW

Table 1.1. Seismic lines provided for interpretation

1.2 Well Data Detail

Table 1.2. Well provided to assist in interpretation

Well name	**Well depth**	**Status**
QAZIAN -01X	2481	Abandoned

1.3 Objectives

- The primary objective of the thesis work is the 2D seismic interpretation.
- Marking of horizons.
- Identification of Faults.
- Construction of fault polygons.
- Preparation of Time and Depth structure maps .
- Reservoir characteristics of the study area by Petrophyscial analysis.
- Facies analysis at the Qazian Well.

1.4 Base map

Base map is important component of interpretation, as it shows the spatial position of each picket of seismic section. For a geophysicist a base map is that which shows orientations of seismic lines and specify points at which seismic data were acquired or simply a map which consist of number of dip and strike lines on which seismic survey is being carried out. A base map typically includes location of lease and concession boundaries wells< seismic survey points and other cultural data such as buildings and roads with geographic reference such as latitude and longitude.

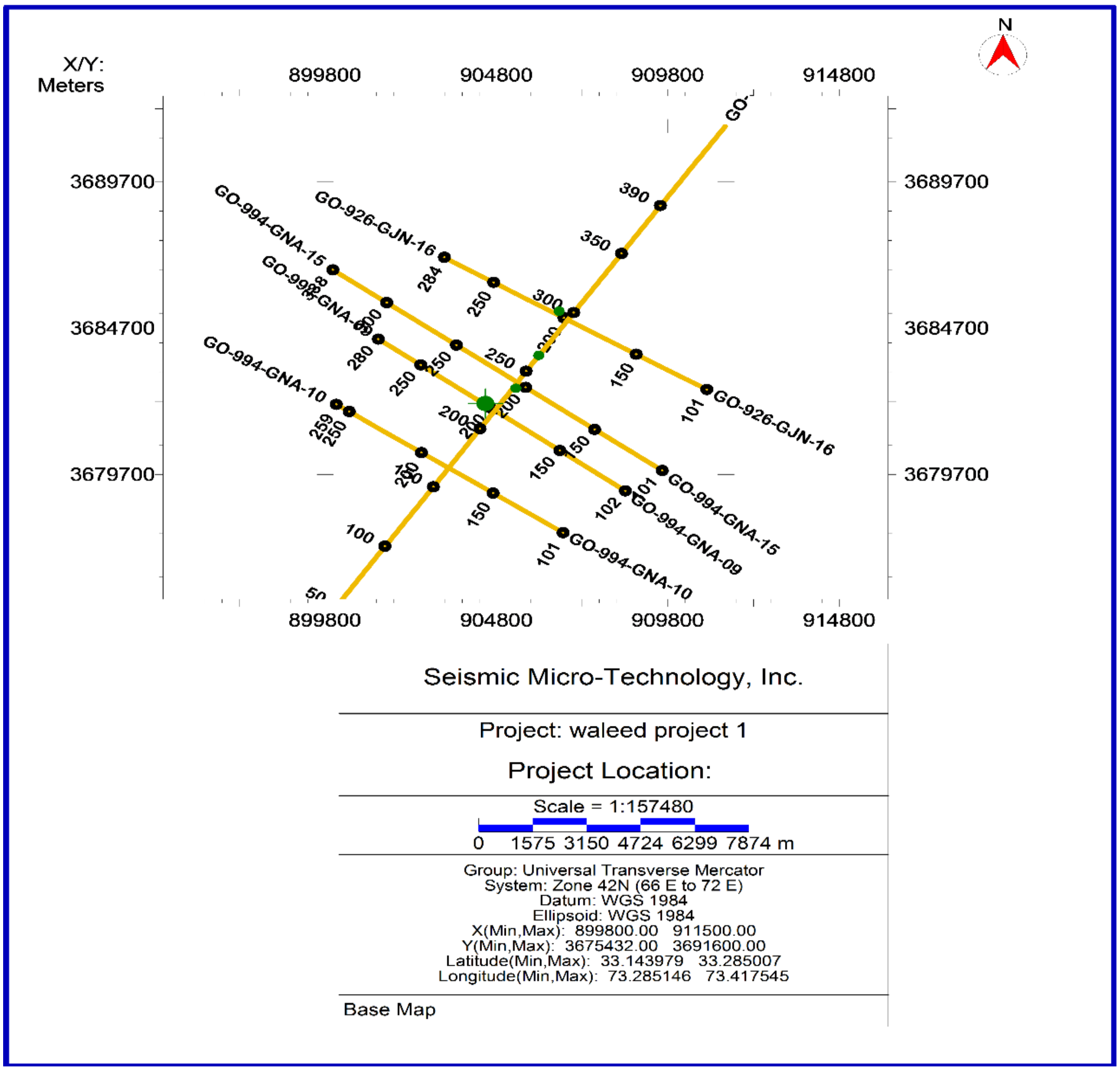

Fig 1.2 Base map of the area

Chapter 2

GEOLOGY

2. Regional Geology of Pakistan

Pakistan is covered of the three broad geological subdivisions that, from North to South, may be referred to as the Laurasian, Tethyan and Gondwanaland domains (Kazmi and Jan, 1997). Their origin may be traced back to Late Paleozoic. In late Paleozoic all the continent had drifted to form a continuous landmass, the super continent of Pangaea. By Late Triassic, Pangaea had split into two super continent, Laurasian to the north and Gondwanaland to the south separated by the Tethys seaway. Pakistan is located at the junction of Gondwanaland and Tethyan domain. Pakistan is unique in as much as it is located at the junction of these two diverse domains. The Southern part of Pakistan belongs to Gondwanaland Domain and is sustained by the Indo-Pakistan Crustal Plate. The Northern most and Western region of Pakistan fall in Tethyan Dom.

2.1 Tectonic Zones of Pakistan

Pakistan can be divided into following tectonic zones, which are:

- Indus plateform and fordeep
- East balochistan fold and thrust belt
- Sulaiman–Kirther Fold Belt
- Bela–Zhob opholitic thrust belt
- NW Himalayan fold and thrust belt
- Indus Suture Zone (MMT)
- Kohistan–Laddakh magmatic arc
- Main Karakoram Thrust (MKT)/ Shyok suture zone
- Karakoram block
- Kakarkhorasan flysh basin
- Makran Accretionary zone and Kharan basin
- Chagai–Ras Koh magmatic arc
- Indus offshore

Qazian area is a part of potwar Plateau which is satuated to the south of the Himalaya and Karakoram Mountains in Northern Pakistan. This area owes its origin to the compressional tectonics at the northern margin of the Indian plates, Subduction of the Indian plate and thrusting in the northern area as an Alpine Himalayan orogeny. Fig 2.2 shows the geological and structural map of potwar plateau.ain and Present a complex geology.

2.2 Basin of Pakistan

Pakistan is comprised of following Basin these includes

1) Indus basin
   a) Upper indus basin
   b) Lower indus basin
      I. Central indus basin
      II. Southern indus basin
2) Balochistan basin
3) Kakar Khoarasan basin (karri, 1995)

2.2.1 Indus Basin

Indus Basin includes the 25000 square Km of South-East of Pakistan. It comprises the Thar-Cholistan desert and Indus Plain. It has 80% of Pakistan population. Tectonically it is much stable area as compare to other tectonic zone of Pakistan. It comprises of buried ridges, platform slop, zone of up warp and dawn warp. (Kazmi & Jan, 1997) Structurally Indus Basin divided into two main parts;

- Upper Indus Basin (in north)
- Lower Indus Basin (in south)

Upper Indus Basin is further divided into two sub basin.

- Potwar sub-Basin
- Kohat sub-Basin.

Lower Indus Basin is also divided into two Basins.

- Central Indus basin (In north)
- Southern Indus Basin (In South)

2.2.2 Upper Indus Basin

It is located in the northern Pakistan and separated from the lower Indus Basin by the Sargodha High. In its north MBT, while in east and west strike slip faults Jhelum and Kalabagh is located, Upper Indus basin is subdivided into Potwar and Kohat Basins along the Indus River (Kazmi & Jan1997). In the Upper Indus Basin Deposition started From Pre-Cambrian. It is only on basin in Pakistan which receive the deposition from Pre-Cambrian time fig 2.1 (Aamir and Siddique, 2006). The general Stratigraphy of Upper Indus Basin is shown in the stratigraphic column, which shows two main unconformities and some small unconformities.

Potwar plateau lies in Western sub-himalayan tectonic zone, This east west trending fold belt comprises the low rolling hills and valleys of the uplifted Kohat-Potwar Plateau, The salt range and its westward extension; it is about 85 km wide and extend for 200km. it is diverted structural zone bounded in the north by north dipping Main boundary Thurst (MBT).

Tectonic of the Potwar plateau is controlled by following factors:

- Slope of the basement (steeperin western Potwar Plateau).
- Thickness of Cambrian evaporates beneath the cover.
- Reactivation of basement brittle tectonics (more enhanced in eastern Potwar plateau).

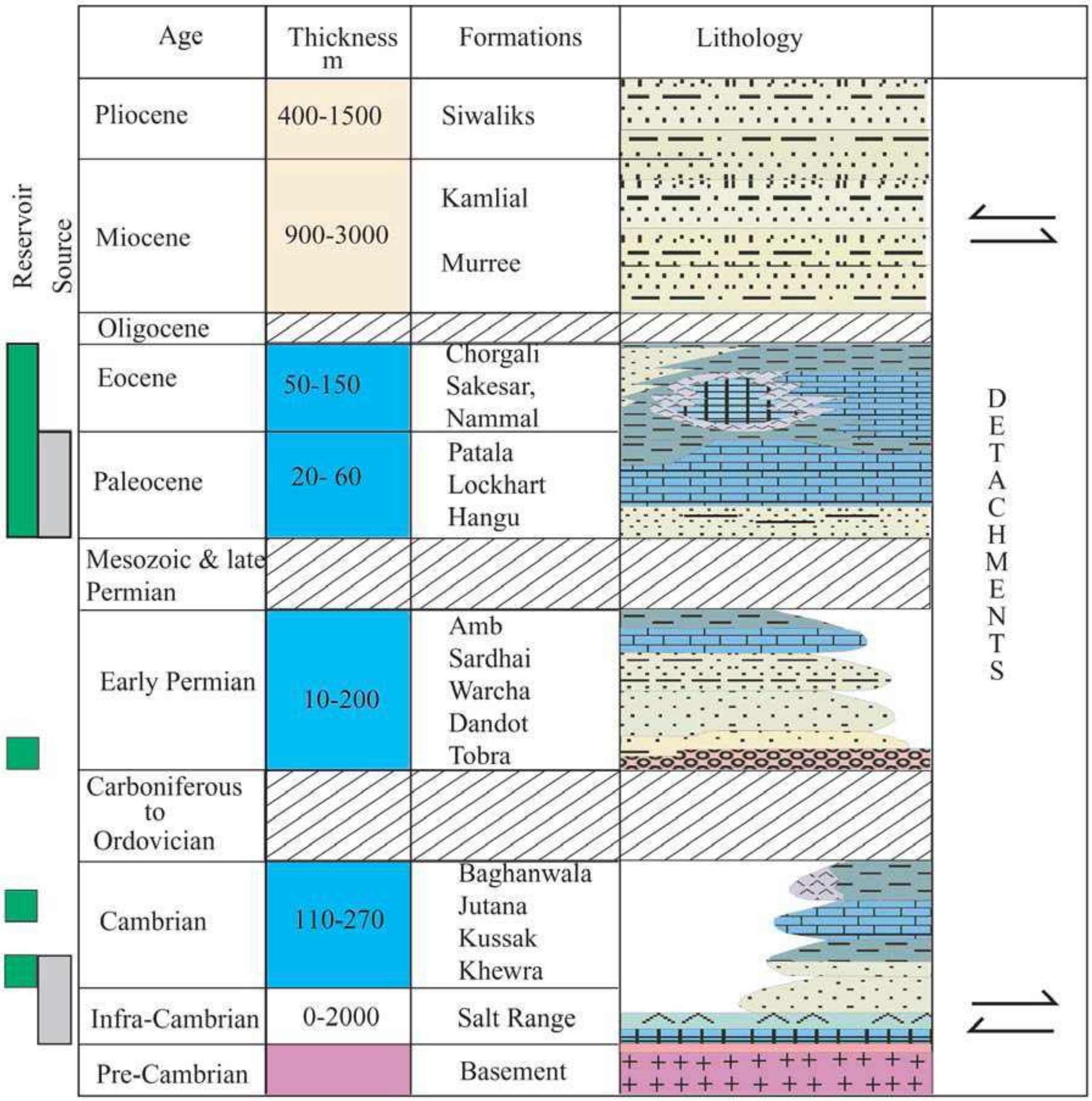

Fig.2.1 Stratigraphy of upper Indus Basin

2.3 General geology of study area

In Seismic method the Reflection seismology (used in present work) is extensively used for hydrocarbon exploration. In Pakistan the potential of hydrocarbon is high in North (potwar, Kohat) and South (Badin, Mari). The Indus basin also including the Kohat and potwar (study area) depression contain 48% of the world's known petroleum resources (Riva, 1983). Structural Traps are most dominated in Potwar sub basin and for the delineation of these structures mostly seismic data is incorporated.

The Potwar plateau is located at the northern margin of Indian plate in northern Pakistan. Well data and surface geology indicate that the Potwar plateau consist of almost entire sequence of lithological succession exposed along the Salt range thurst and therefore the Potwar plateau is a prolific area for hydrocarbon occurrence. The first commercial discovery of hydrocarbons from the Himalayan foreland was made in the Potwar plateau. Since then hydrocarbons have been reported from different areas of Potwar Plateau.

The potwar plateau and especially the northern part exposed along the Main Boundary Thrust (MBT) has experienced severe deformation during the Himalayan Orogeny in Pliocene to Middle Pliocene(e.g. Jaswal, 1990; Jadoon et al, 1997; Johnson et al, 2009). Surface geological features at some parts of the Potwar plateau mismatch the surface geometry due to complexities involved at the upper and middle crustal levels(Mcdougall & Hussain, 1991). In this study, surface structural elements and subsurface geometries will be integrated in the light of existing geological maps and seismic section.

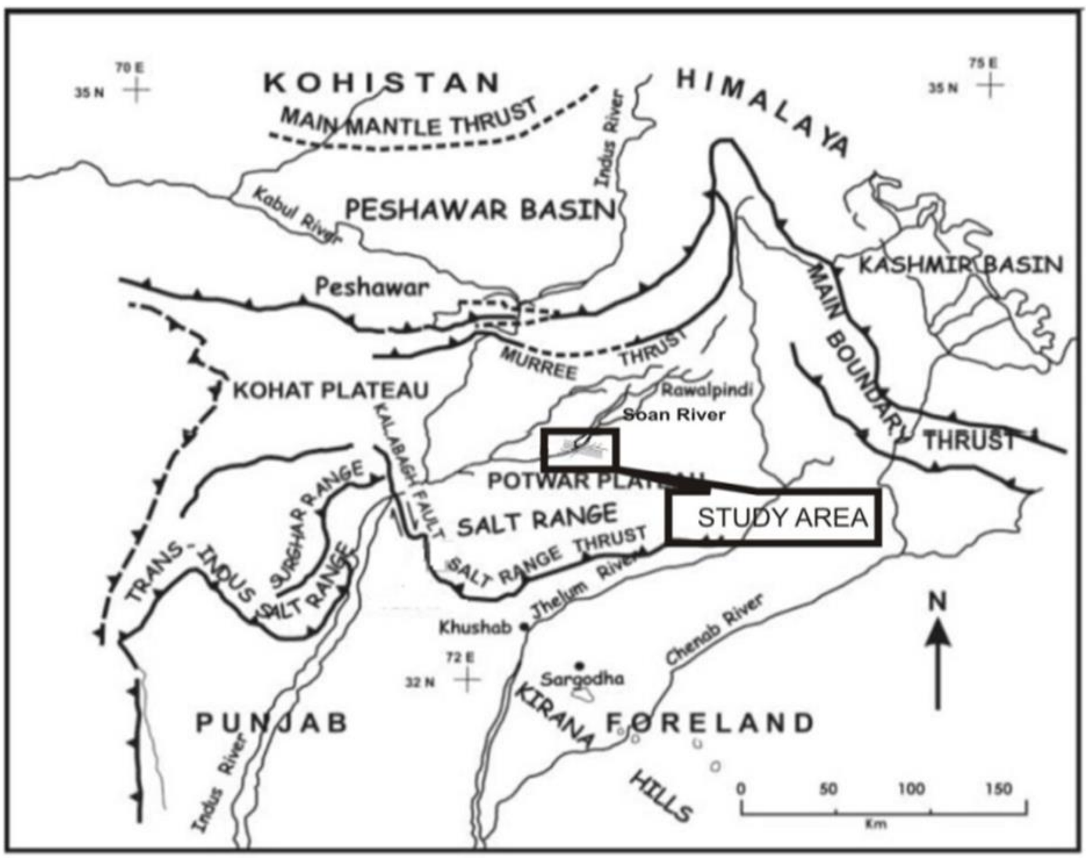

Fig 2.2 Geological and structural map of Potwar plateau

2.4 Lithological Description of Formations

The stratigraphic section encountered in Qazian 1 (Table 2.1) confirms the different reflector depths interpreted in Geo Seismic section

Following are the lithological description of the section drilled at Qazian 1 which was drilled down to a depth of 2457 meter into formations of post Cambrian age. The Formation tops were initially picked at the well site, which were further refined / confirmed by the electric logs. A list of final formation tops and thickness drilled in Qazian 1, are presented in the (Table 2.1).

FORMATION	TOPS FROM LOCAL DATUM (M)
Chinji	0
Kamlial	1031
Murree	1199
Chorgali	2062
Sakesar	2107
Namal	2181
Patala	2195
Dandot-Tobra	2225
Baghanwala-Jutana-Kussak	2258
Khewra	2343
Salt range	2457

Table 2.1 Formation tops of well Qazian-01X

2.5 Petroleum play of study Area

In the potwar basin petroleum and gas exploration has a long history. To confirmation of structural play we more focus to designation new play fairways. The faulted anticline structures are mostly covered with salt in potwar basin which are occasionally highly asymmetrical to overturn. Which are mostly salt cored, occasionally highly asymmetrical to overturn. An abundant fracturing in eastern part as compared to western part.

2.5.1 Source Rock

The source rock of Infra-Cambrian to Eocene in the Potwar basin is identified by manycompanies. In Potwar basin the organic-rich shale of Paleocene age (Patala Formation) is the main source of Potwar Oil filed. (Bender, et al, 1995).

In Potwar Basin, Patala shale of Paleocene have proven as the main source rocks. Due to buckling of basin floor the organic shale of Paleocene age were partly deposited in anoxic conditions. The oil shale intervals contain in Precambrian Salt Range Formation, which show potential of source rock

2.5.2 Reservoir Rock

Marine sedimentary rocks of Paleozoic-Tertiary form petroleum systems in Potwar and are exposed in Salt Range along the Frontal Thrust. The Sakesar and Chorgali Formations have fractured carbonates that are major producing reservoirs in Missa kaswal.

2.5.3 Cap/Seal

Due to thin-skinned tectonics Traps have been developed, which has produced faulted anticlines, pop-up and positive flower structures above Pre-Cambrian salt. The clay and shale of the Murree Formation also provide efficient vertical and lateral seal to Eocene reservoirs wherever it is in contact.

Chapter 3

Seismic

Interpretation

2 Seismic Interpretation

The Seismic Interpretation is a method of determining information about the subsurface of earth from seismic data. It may determine general information about an area, locate prospects for drilling exploratory wells or guide development of an already discovered field. (Coffen, 1986). Those reflections and unconformities which are to be mapped on seismic section, which fully describe the geology and hydrocarbon potential area (Badley, 1985).

To get the complete interpretation requires gathering all the relevant data which would be helpful in providing the accurate results. The basic study of reservoir characterization which would be determined step by step starting with the seismic interpretation. The base map of the Missa Kaswal area with imposed well location is shown in the fig 1.2 (Base map of area), which shows the location of well QAZIAN -01X on dip line GO-994-GNA-09. By seismic interpretation, we pick reflector from the time section. The reflector on the time section are marked by using well tops and confirm with the generation of synthetic seismogram and its correlation with the time section GO-994-GNA-08(STRIKE LINE). The rest of dip line reflectors are marked with the help of synthetic correlated seismic section. Therefore, the picking of the reflector of our interest on time section gives the accurate result of our interpretation. In horizons section, the recognition of the main sequence boundaries and introduction of well data, allowed calibration of seismic times to a common datum and resolved the potential stratigraphic problem.

3.2 Interpreter's Objectives

An interpreter should clearly understand and should not be uncertain about conclusions that are to be extracted from seismic data. As sufficiently of information is available on seismic record, it is compulsory to focus primarily on extracting the data pertinent to task.

3.3 Interpretation Process

The first step in the interpretation process is to judge the reflections and faults. If existing on seismic time section. Those reflections are selected which are real, show not good character and even continuity of reflectors was not so good.

Base map is prepared by loading navigation data and SEG-Y in software Kingdom 8.8. Horizons of interests are marked manually with the help of synthetic seismogram. In this processfaults are also marked and identified on seismic section. Faults polygons are generated and horizons are contoured to find out structural high and lows. The interpretation workflow is discussed in Fig 3.1

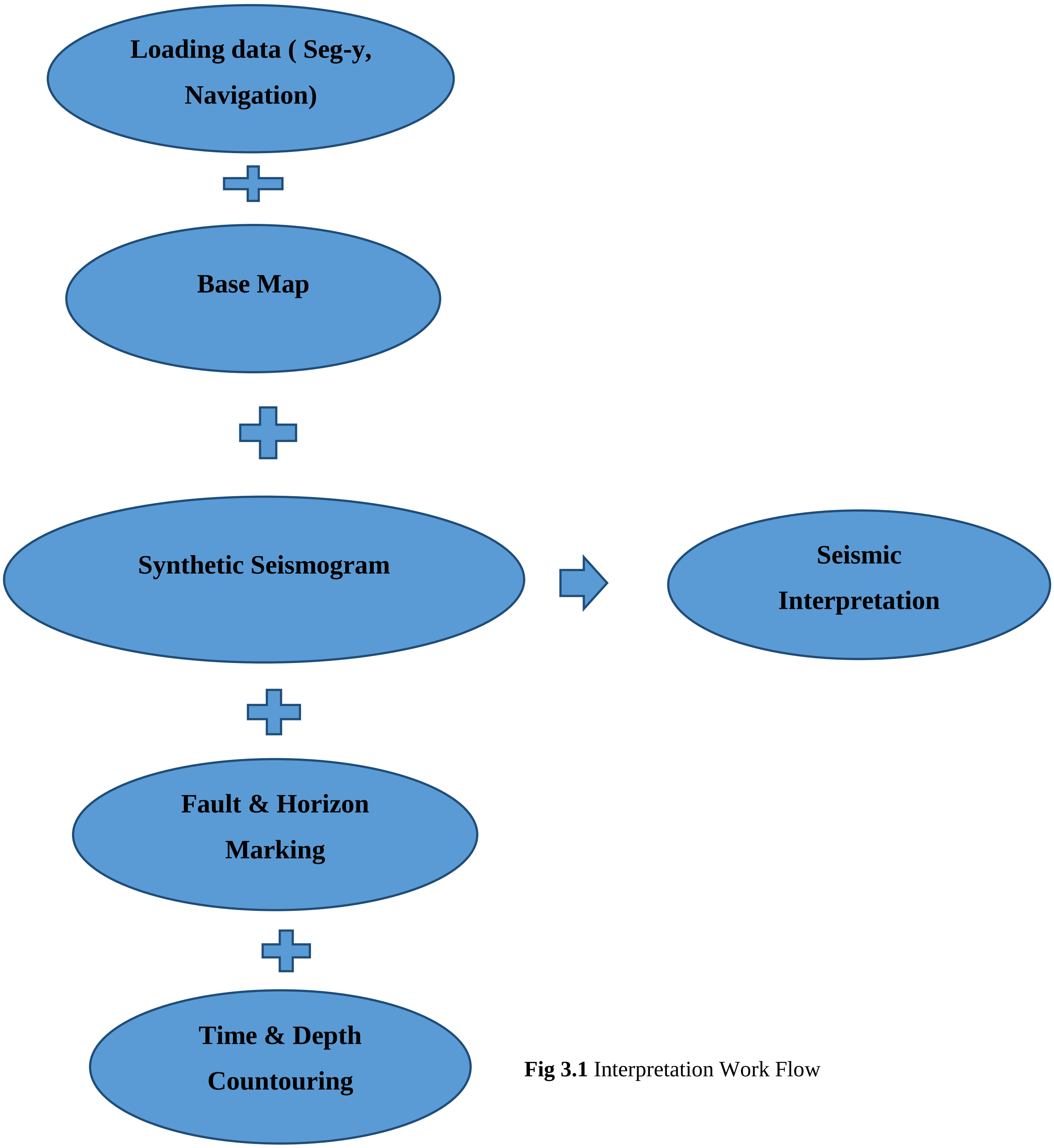

Fig 3.1 Interpretation Work Flow

3.4 Available Data

Five seismic lines, base map, and well tops of well Qazian-01x acquired from DGPC for this project.

Available seismic lines are as follows:

- GO-905-QZN-08
- GO-994-GNA-09
- GO-994-GNA-10
- GO-905-QZN-15
- GO-994-GNA-16

3.5 Synthetic Seismogram

Synthetic seismogram was generated by convolution of Sonic, density curve with the source wavelet of the well Qazian- 01x. The source wavelet used was extracted wavelet shown in fig.3.2.

Basic and most important step of interpretation is generation of synthetic seismogram. It provides a crucial link between lithological variations within a drill hole and reflectors on seismic profiles crossing the site. In essence, they provide a ground truth for the interpretation of seismic data. Synthetic seismogram are useful tools for linking drill hole geology to seismic sections, because they can provide link between observed lithologies and seismic reflection patterns. Reflection profiles are sensitive to changes in sediment impedance, the product of compressional wave velocity and density. Changes in these two physical parameters do not always correspond to observed changes in lithologies. By creating a synthetic seismogram based on sediment petro-physics, it is possible to identify the origin of seismic reflectors and trace them laterally along the seismic data as we use Qazian-01X data to generate synthetic seismogram for marking the horizons on seismic sections.

Well tops were also imposed on the respective synthetic seismogram showing chorgali, Sakesar, Hangu, patella, Lockhart, Nammal, Tobra, Dandot, Bangawala and Khewra sandstone Formation respectively as shown in fig.3.2.

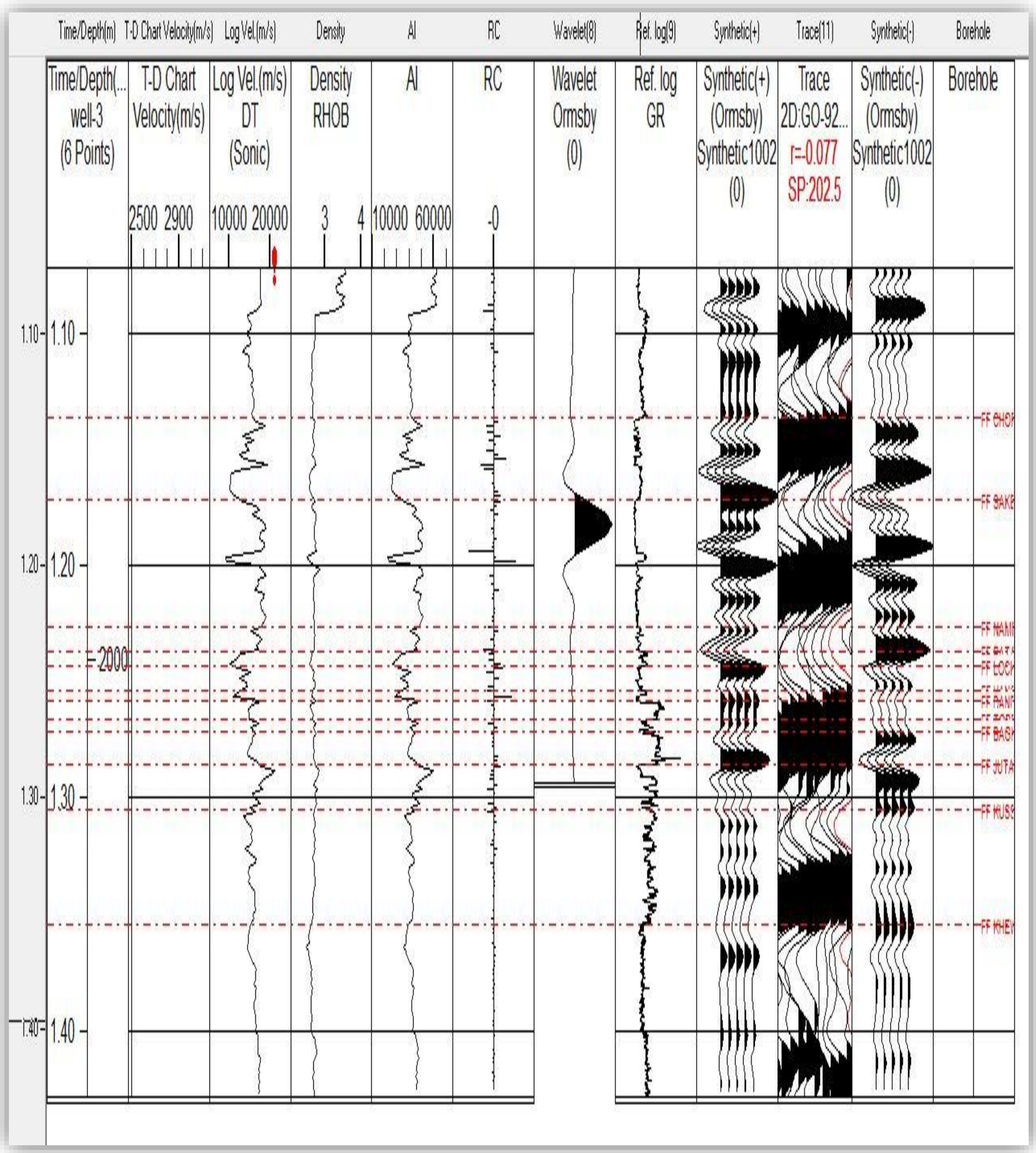

Fig 3.2 Synthetic seismogram

3.6 Identification of Horizon and Faults

The first step in interpretation of a processed seismic section is to pick up the best seismic reflectors from the seismic section. Reflectors are marked on the basis of prominent coherence of reflections visible, which appeal you most on the seismic section from the above subsurface interface. Two reflector were marked in the seismic section of the study area, which are designated as chorgali and Khewra as show in fig 3.3.

The identification of various horizons as an interface between geological formations is one of the basic task of interpretation. For this purpose, good structural as well as stratigraphic knowledge of the area is acquired (Mavko et al, 2009). Thus during the interpretation process both horizons and faults were marked on the seismic section. Two horizons Bhadar/chorgali and khewra were marked. The horizons are named and marked on the basis of well tops encountered in the Qazian X-01 well which are showing high reflections on the seismic section making it easier to be picked. Marked section are shown is Fig 3.3, 3.4, 3.5 and 3.6 for dip lines given and Fig 3.7 shows strike line. Two Horizons(Bhadar/chorgali and khewra) were marked on them. Also the thurst faults have been marked.Faults are the broken reflectors in seismic section, which continues after slight distortion regime. Major two faults were marked in the seismic section as show in figures.

Line GO-994-GNA-09

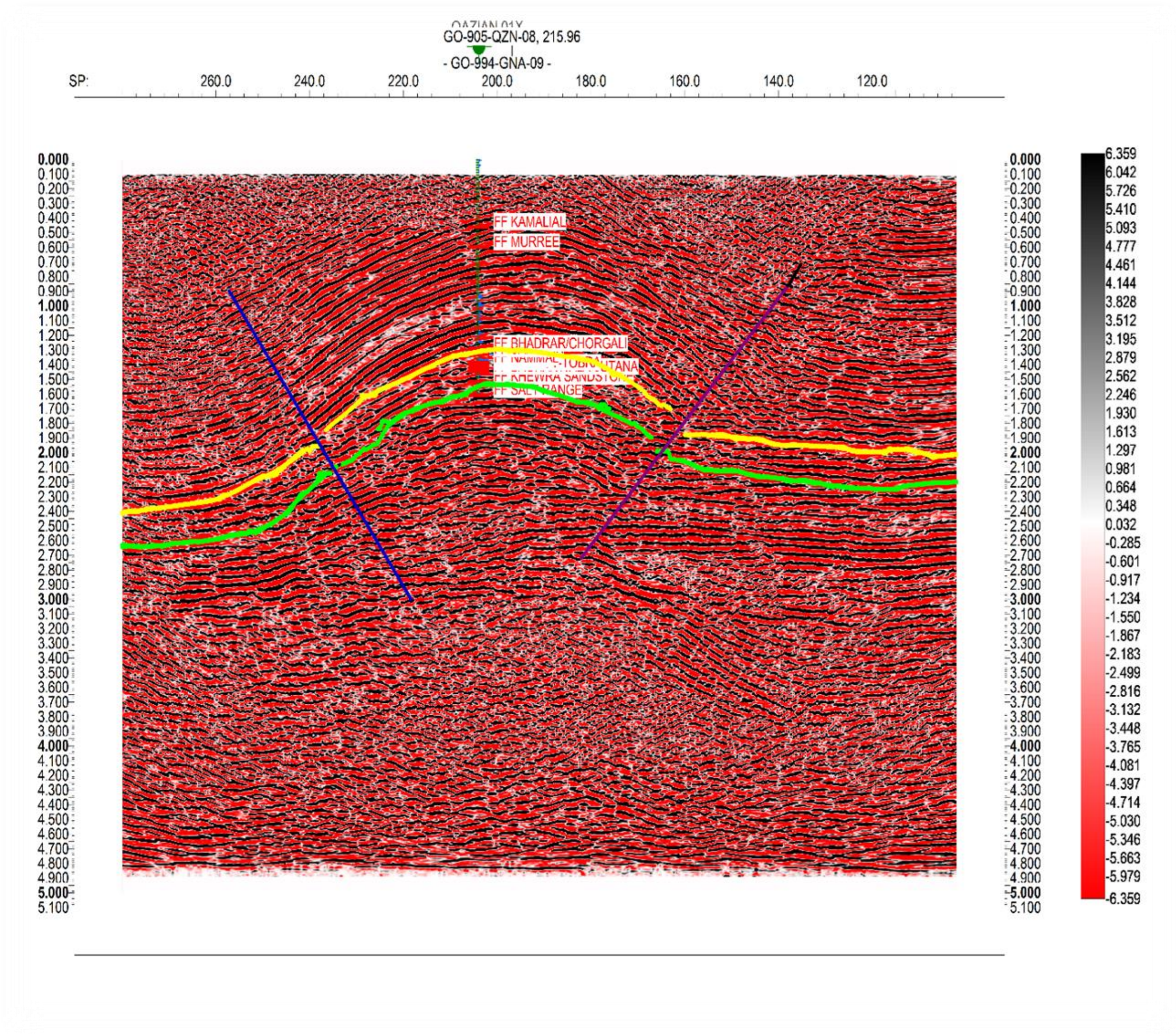

Fig 3.3 Marked section of line GO-994-GNA-09

In the figure 3.3 the faults, F1 and F2 are marked on the line GO-994-GNA-09. The horizons which are marked are the Chorgali, and the Khewra sandstone. , The Chorgali formation is shown with the yellow color horizon. The Khewra sandstone is shown with the green color horizon line. The marked section shows compressional regime characterized by thrust faulting and anticline structures. The line type is dip line and its orientation is from NW- SE.

Line GO-994-GNA-15

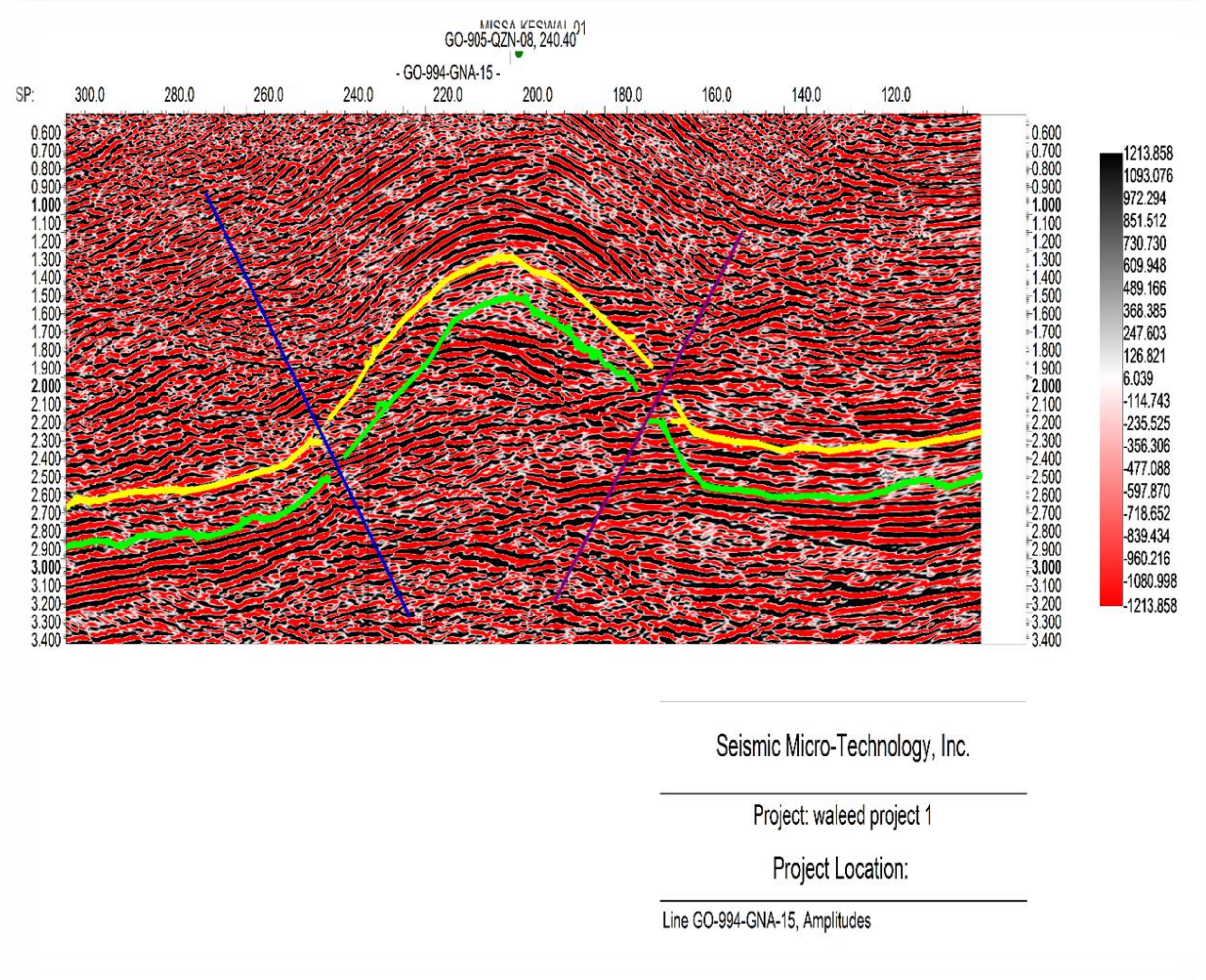

Fig 3.4 Marked section of line GO-994-GNA-15

In the figure 3.4 An anticlinal pop up structure is marked on the seismic sections with two thrust faults F1 and F2 dipping towards each other from east and west.The Chorgali formation is shown with the yellow color horizon. The Khewra sandstone is shown with the green color horizon line. The marked section shows compressional regime characterized by thrust faulting and anticline structures. The line type is dip line and its orientation is from NW- SE.

Line GO-994-GNA-16

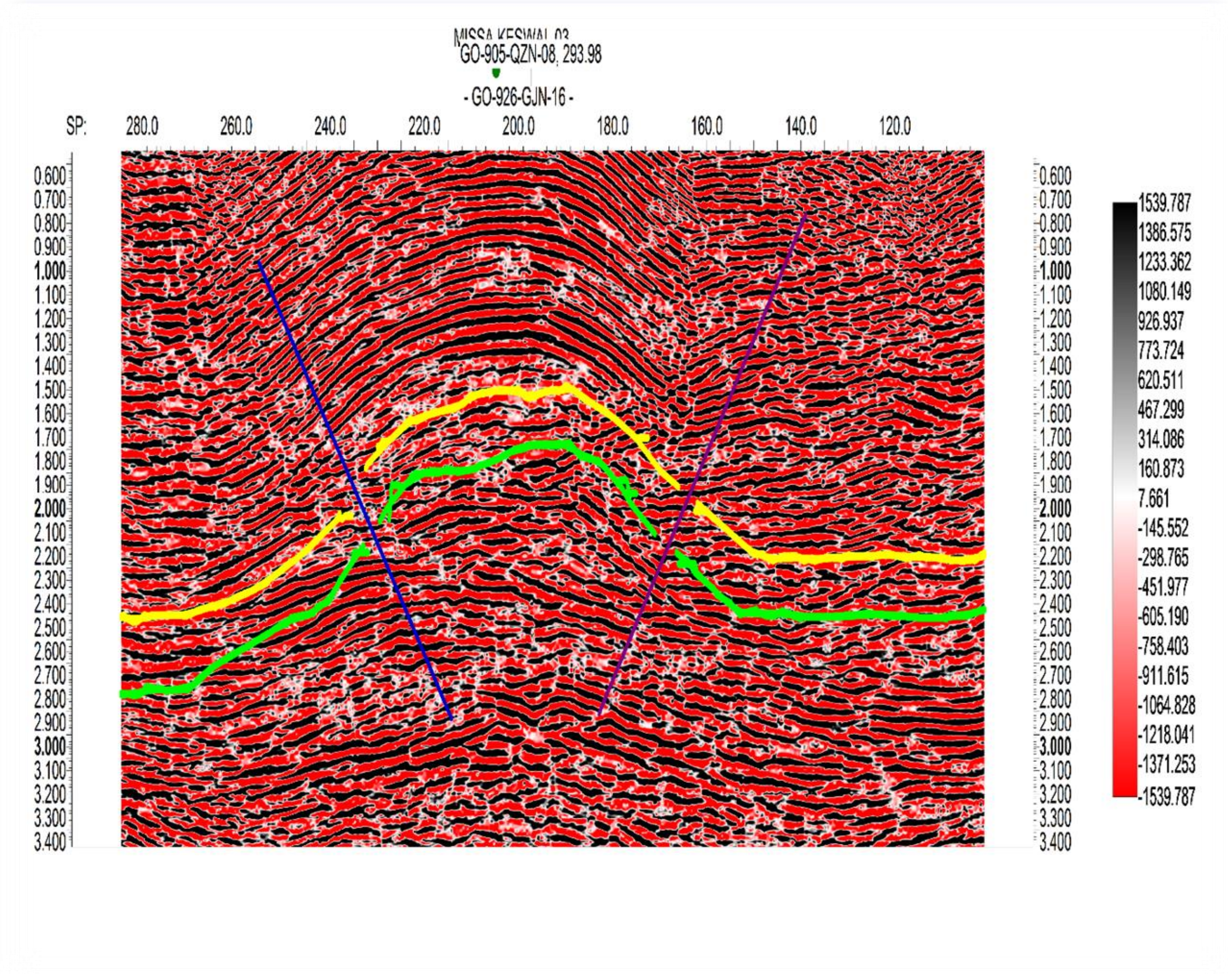

Fig 3.5 Marked section of line GO-994-GNA-16

In the figure 3.5 the faults, F1 and F2 are marked on the line GO-994-GNA-09. The horizons which are marked are the Chorgali, and the Khewra sandstone. , The Chorgali formation is shown with the yellow color horizon. The Khewra sandstone is shown with the green color horizon line. The marked section shows compressional regime characterized by thrust faulting and anticline structures. The line type is dip line and its orientation is from NW- SE.

Line GO-994-GNA-10

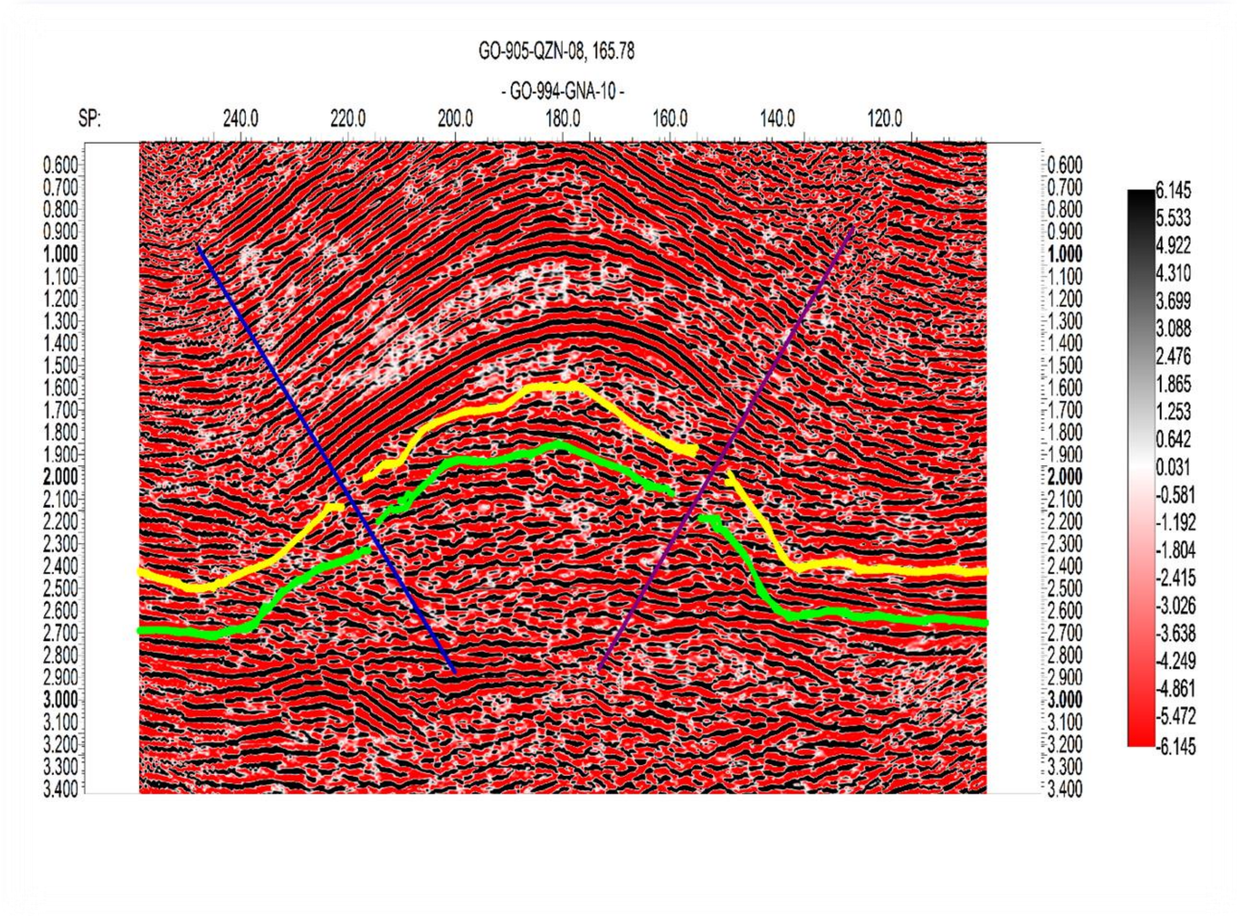

Fig 3.6 Marked section of line GO-994-GNA-10

In the figure 3.6 An anticlinal pop up structure is marked on the seismic sections with two thrust faults F1 and F2 dipping towards each other from east and west. The Chorgali formation is shown with the yellow color horizon. The Khewra sandstone is shown with the green color horizon line. The marked section shows compressional regime characterized by thrust faulting and anticline structures. The line type is dip line and its orientation is from NW- SE.

Line GO-944-GNA-08

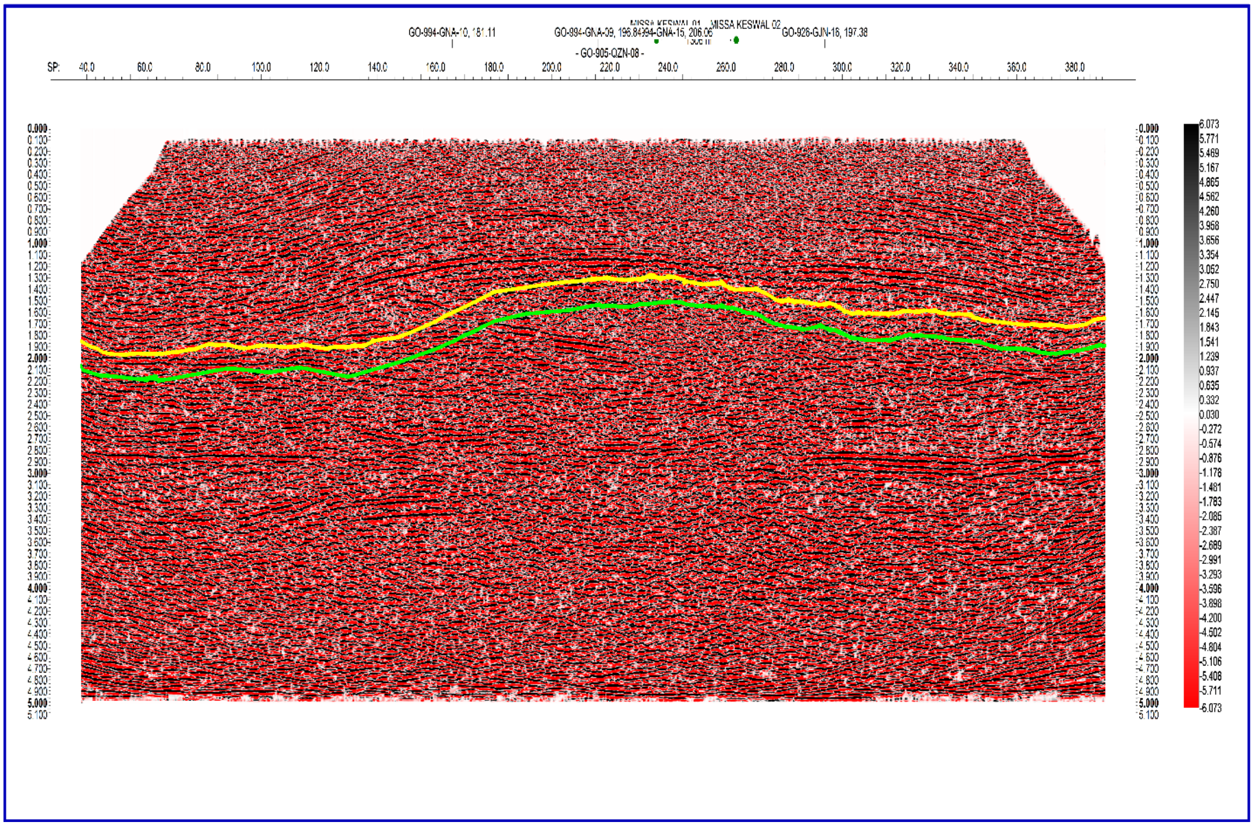

Fig 3.7 Marked section of line GO-944-GNA-08 (strike line)

In the figure 3.7 The Chorgali formation is shown with the yellow color horizon. The Khewra sandstone is shown with the green color horizon line. The marked section shows compressional regime characterized by thrust faulting and anticline structures. The line type is strike line and its orientation is from NE – SW.

3.7 Construction of fault Polygon

Marked seismic section are collectively used to generate fault polygons as any mapped software needs all faults to be converted into polygons prior to contouring. The reason is that if a fault is not converted into polygon, software doesn't recognize it as a barrier or discontinuity, thus making any possible closures against faults represents a false picture of subsurface structures.

3.8 Contour maps

Contour lines are representative of the same events. The results of seismic interpretation are generally demonstrated in map form. Mapping is part of the interpretation of the data. The seismic map is generally the final product of seismic exploration, the one on which the entire operation depends for its usefulness. The contours are the lines of equal time or depth wandering around the map as dictated by the data (Coffeen, 1984).

The layout of the contour lines is a measure of the steepness of the slope; the closer the spacing the steeper the slope. A subsurface structural map shows relief on a subsurface horizon with contour lines that represent equal depth below a reference datum or two way time from the surface. These contour maps reveal the slope of the formation, structural relief of the formation, its dip and any faulting and folding. The picked times for each reflector are exported along with the navigation data in the form of an XYZ file to be used for contouring. The Kingdom suit is used to generate all the contour maps.

3.9 Time Contouring

Seismic sections gives the time value along shot points and the times are read directly from the sections and are immediately available for mapping. After completing horizons and fault interpretation time contour map are constructed. Time variation is mentioned through the color bar template from shallowest to deepest.

The pattern of time contour map confirms the shape of the subsurface structure. Time contour maps of these formations shows 2D- variations with respect to time and the Hydrocarbons probably accumulate at those places where time contour values are low hence low pressure zone.

Low pressure zones are the favorable site for hydrocarbons accumulation and we look for such zone to dig wells. Deciding the new well location for our study area we have to mark the low pressure zone and is mostly the zone present nearest to the surface. Fig 3.8 shows time contour map of Bhadat/Chorgali while Fig 3.9 shows time contour of khewra.

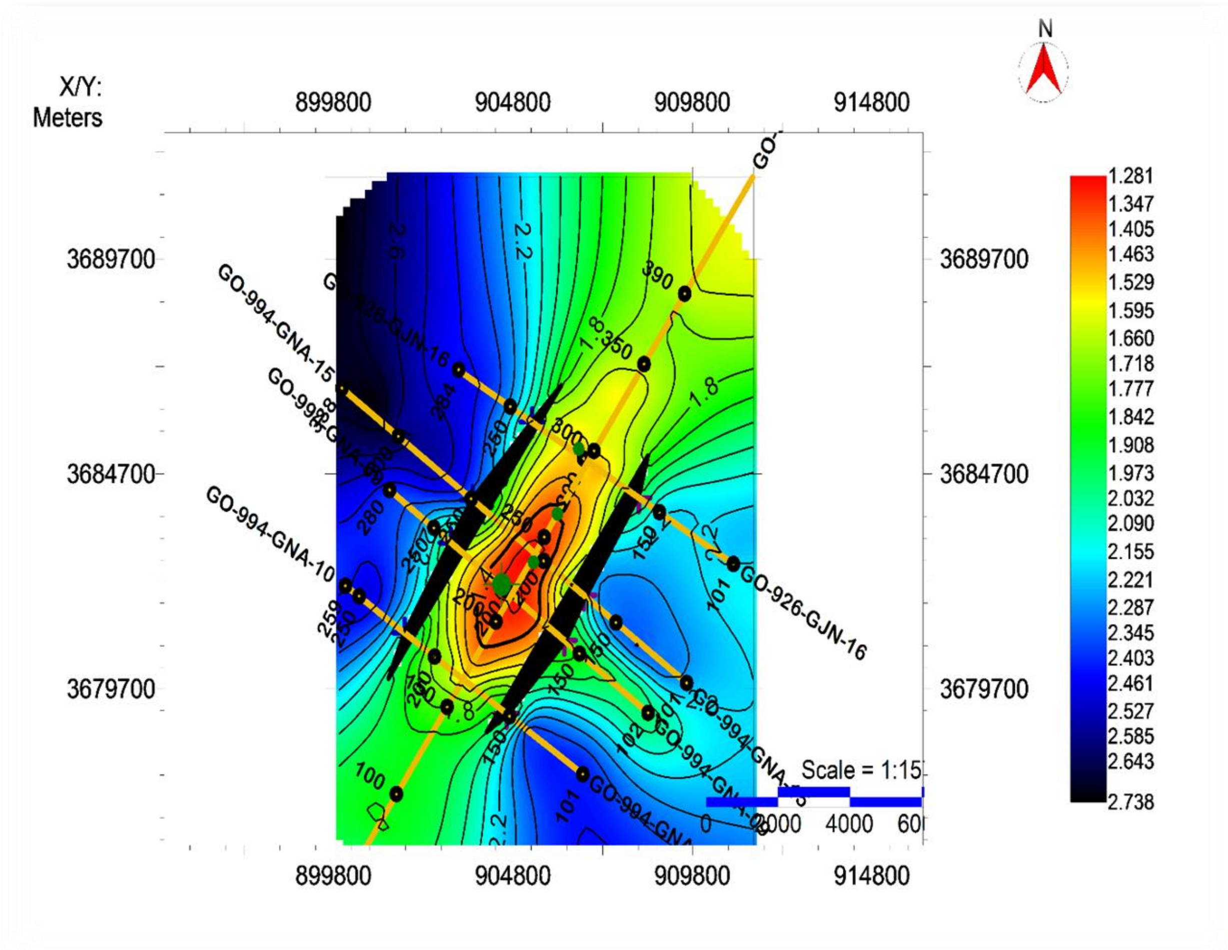

Fig 3.8 Time contour of Bhadrar/Chorgali

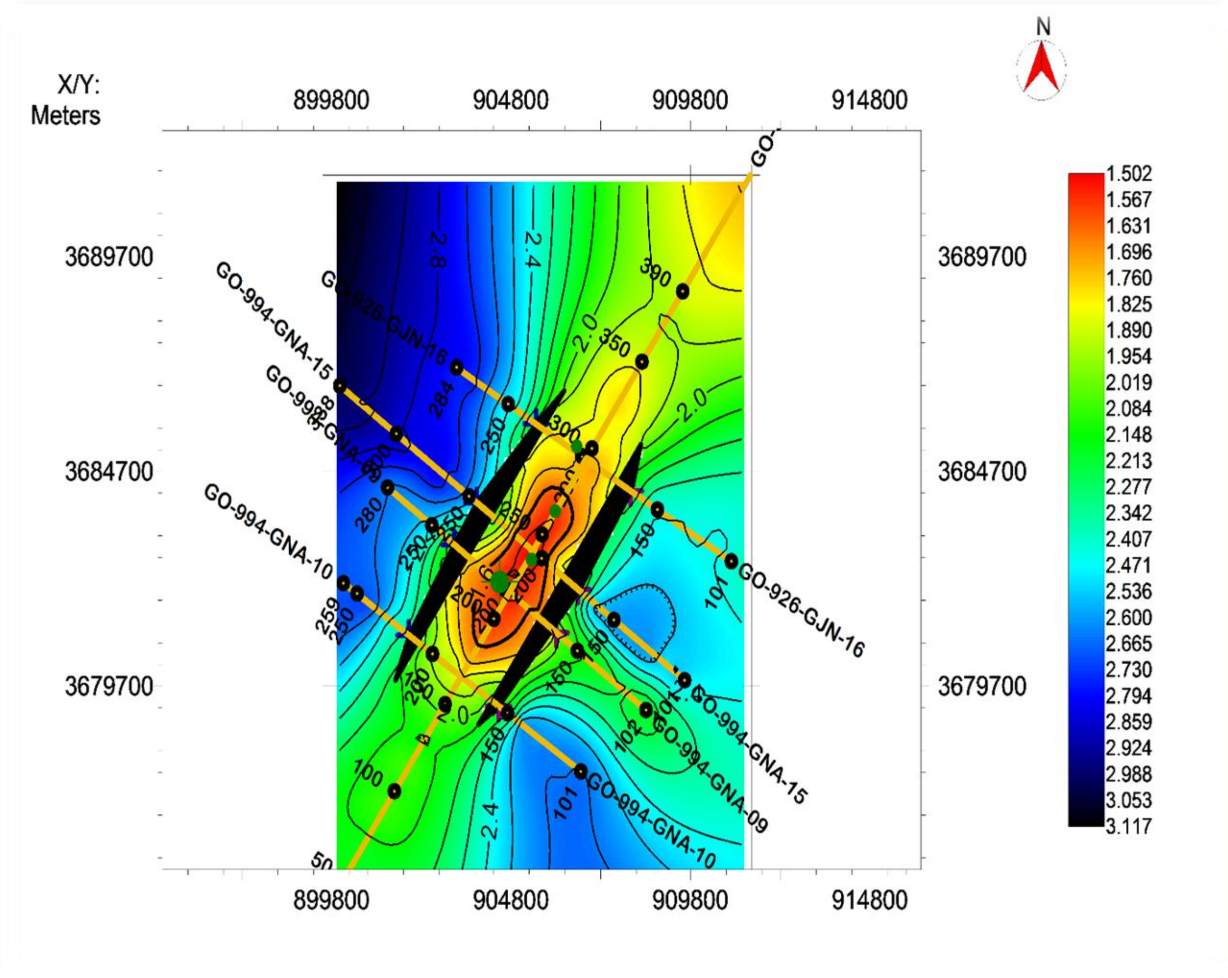

Fig 3.9 Time contour of Khewra

3.10 Depth Contouring

Our primary information is the varying time values and by using these values and subsurface velocities depth conversion is done. Depth conversion and depth contour maps are connected to see the horizons in the subsurface at their true positions. Depth must be calculated from time to make a map that is more truly related to the subsurface shapes, because structures is a matter of depth. The idea of converting the times into depths is very reasonable in case of showing the subsurface structures. Depth contour is showing same pattern to the time contour as constant velocity is multiplied with time.

Fig 3.10 and Fig 3.11 are showing the depth maps of Bhadhrar/Chorgali and Khewra. Depth variation is mentioned through the color bar template from shallowest to deepest.

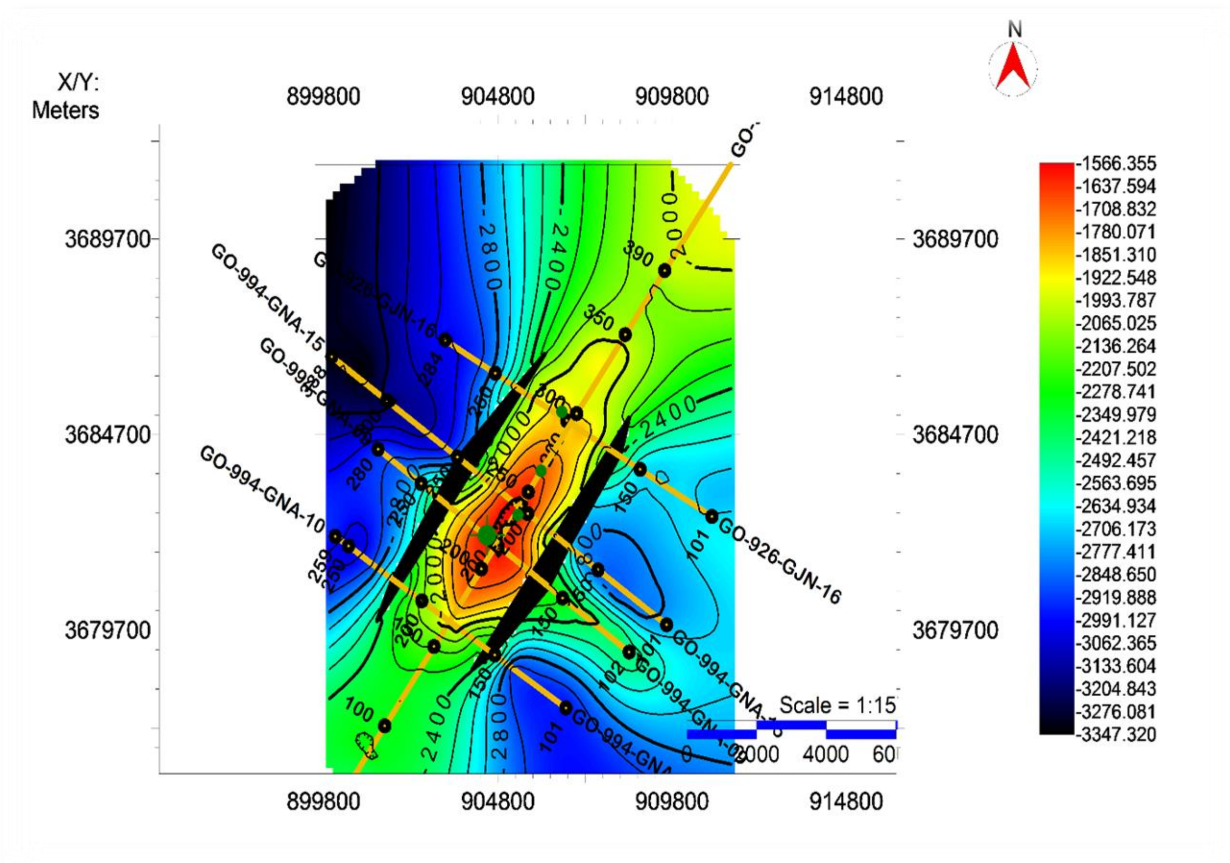

Fig 3.10 Depth Contour of Bhadhrar/Chorgali

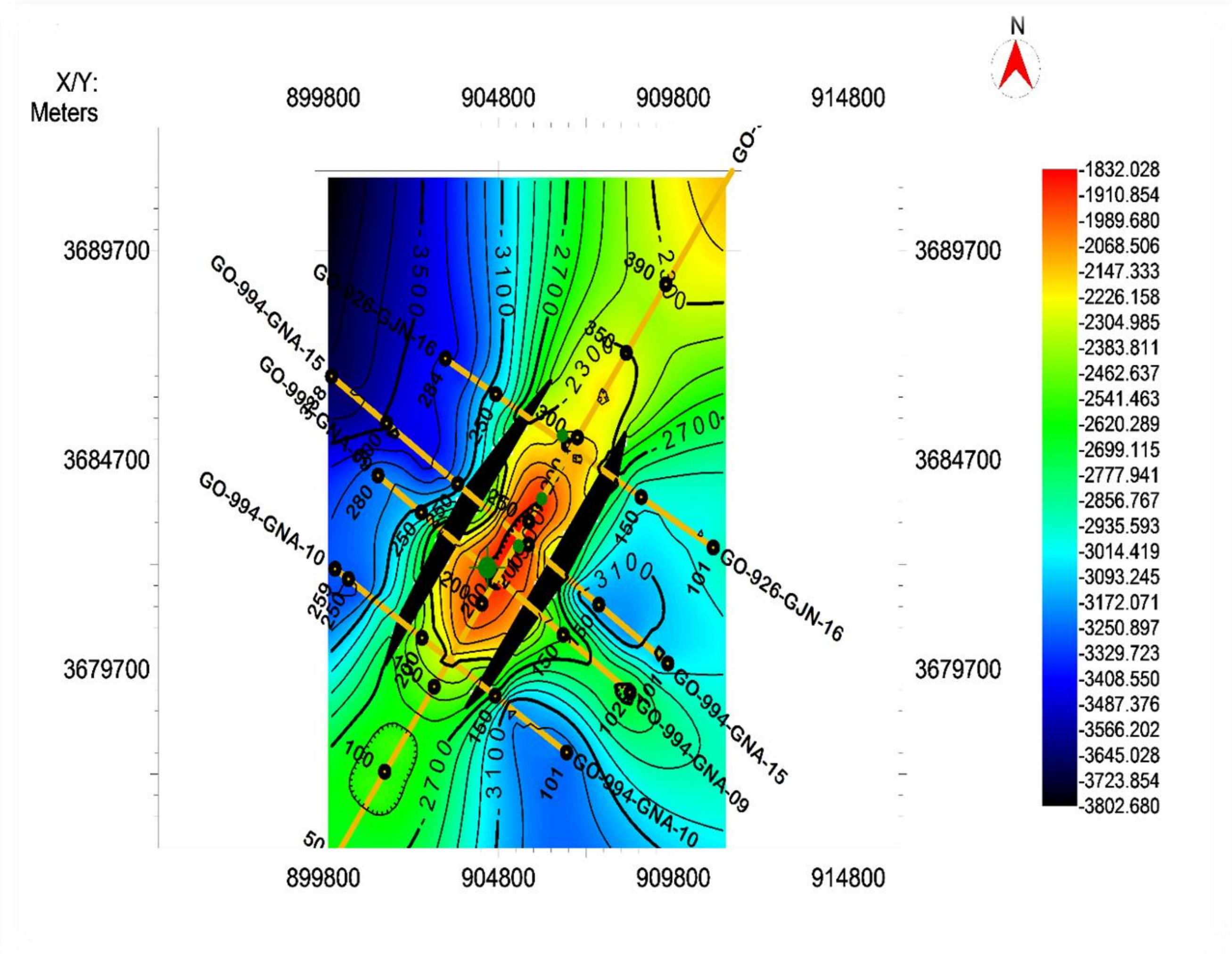

Fig 3.11Depth Contour of Khewra

Chapter 4

Petrophysical Analysis

3 Petrophysical Analysis

Petrophysics is the study of rock properties and their interactions with fluids (gases, liquid, hydrocarbons and aqueous solutions). Because petroleum reservoir rocks must have porosity and permeability, we are most interested in the properties of porous and permeable rocks.

Petrophysical Analysis provide a method of deriving accurate values for the hydrocarbons and water saturation, the permeability, the porosity and the lithology of the reservoir rock.

Petrophysics uses all kind of logs, core data and production data and integrates all pertinent information. It aims at obtaining the physical properties such as porosity, saturations and permeability, which are related to production parameters. It is generally less concerned with seismic, and more concerned with using wellbore measurements to contribute to reservoir description.

Petrophysics can provide things like

- Porosity
- Permeability
- Saturation
- Net pay
- Fluid contacts
- Shale volume
- Reservoir zonation

Petrophysics is the interests of Petroleum Engineers, Well Log Analysts, Core Analysts, Geologists and Geophysicists (Dewar 2001).

4.1 Classification of geophysical well logs

Different classifications and some short explanation of geophysical well logs is as follow. The logs are explained according to the tracks in which they are run and this is clear from the flow chart given below

Lithology track

In lithology track the following three logs are displayed which are explained as follow**.**

- Gamma ray (GR)
- Spontaneous Potential log (SP)

Gamma ray log

GR log is also known as shale log is measurement of formations radioactive contents. Since radioactive contents are present in shale so it gives deflection where shale is present that's why it is best log for lithology identification.

Spontaneous potential log

SP log measures the naturally occurring potential of geological formations no artificial currents are injected. It gives deflection opposite to permeable beds since shale is impermeable so it gives straight line opposite to shale known as shale base line. It is used

- To indicate permeable zone
- Identify bed boundaries
- To calculate volume of shale.
- To calculate resistivity of formation water

Caliper log

Caliper log use to measure the borehole size. This log give us help to identify the cavity washouts and break outs. Hence this log is also called the quality check for other logs. Because if any where there is say wash out then in front of the wash out the porosity and resistivity log will not give the correct reading. Hence caliper log is very important in Petrophysical logs

Porosity log

DT, RHOB, and NPHI are porosity logs which are used to calculate pore volume of formations. With the combination of resistivity logs they are used to calculate water saturation of formations.

Porosity log contains

- Sonic log (DT)
- Density log (RHOB)
- Neutron Porosity log (NPHI)

Sonic log.

Sonic log produce compressional waves and measure the transient travel time of waves. Where travel time is higher it is indication of porous media because wave is name of progressive disturbance of media if media is porous travel time is higher. It is used

- Porosity (using interval transit. Time)
- Lithology identification (with Neutron and/or Density)
- Synthetic seismograms (with Density)
- Mechanical properties of formation with (Density)
- Abnormal formation pressures detection

Density log

Gamma rays are bombarded on formation these are scattered from formation's electrons higher the scattering higher the electron density and this electron density is related to bulk density of rocks. Lower the density higher the porosity of medium.

Neutron log

Neutron log tool emit high energy neutron and the only resistive substance to neutron are hydrogen ions. If value of this log is high it means high hydrogen ions concentration is present. Since hydrogen ions are present in pore space so neutron log measures porosity. If gas is present than value of log is low because concentration of hydrogen ion is low.

Electrical resistivity log

Basically there are different types of electrical Resistivity Logs. Logs of LLS and LLD can separate only when (oil) high resistive fluid is present in the formation. It is explained in detail in Petrophysical interpretation.

- Laterelog Deep (LLD)

- Laterelog Shallow (LLS)

Laterelog deep

Laterelog is used for deep investigation of the undisturbed zone (Uninvaded zone) and it is called Laterelog deep (LLD). This log is also used for saline muds also in case of fresh mud. This log is generally used for measuring the formation resistivity. IT having deep penetration as compared to the (LLS).

Laterelog shallow

Laterelog shallow (LLS), used for shallow investigation of the transition zone / invaded zone. Because the depth of the investigation is smaller than the LLD .

4.2 Logs used

- Density log
- Sonic log/porosity log
- Gamma ray log
- Caliper Log
- Spontaneous Potential log
- Resistivity log
- Neutron log
- LLD and LLS

4.3 Log curves

The log information of QAZIAN -1x was accessible in Logging ASCII Standard (LAS) format. All the parameters (hydrocarbon saturation, water saturation, volume of shale and porosities) are calculated by using information given in header and LAS file. The method used is given in (figure 4.1) the procedures of each analysis is discussed step by step (Figure 4.2) shows the different log curves. There is a inverse relation between water saturation and hydrocarbon saturation.

SW+HS=1

HS=1-SW

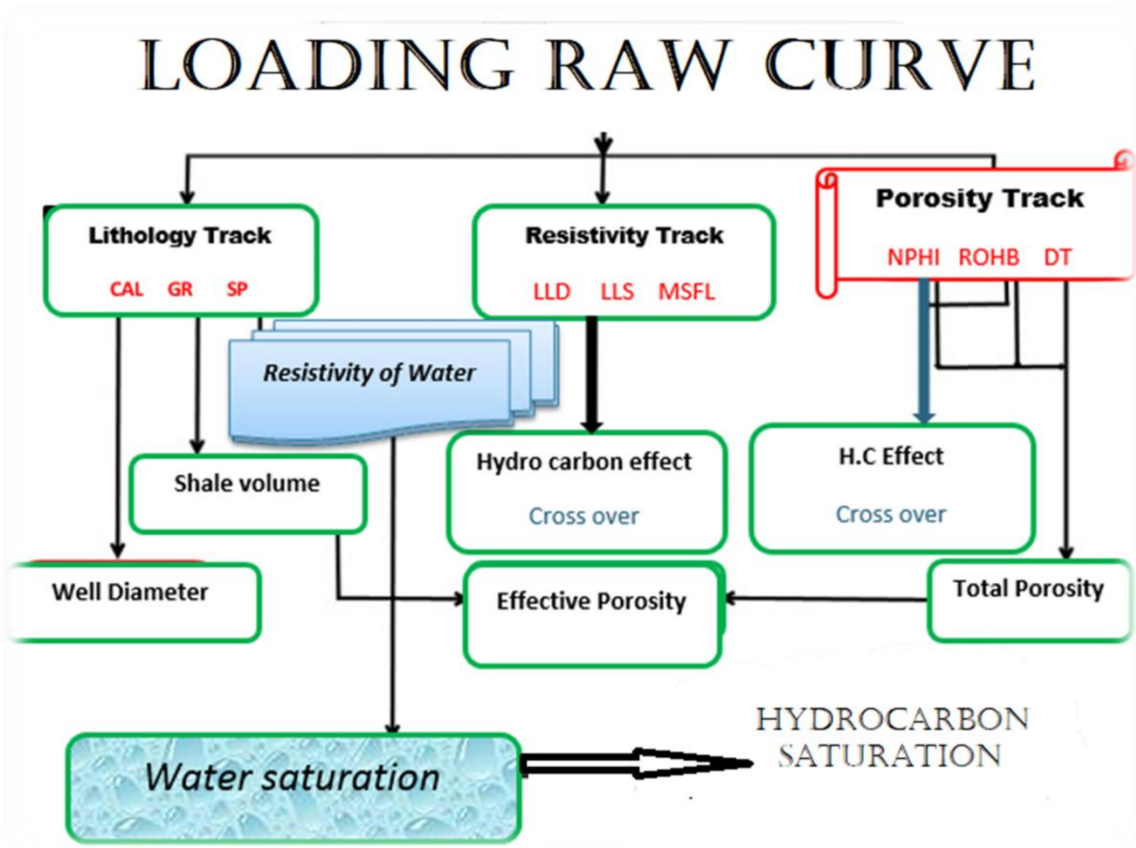

Figure 4.1: Processing steps for Petrophysical analysis

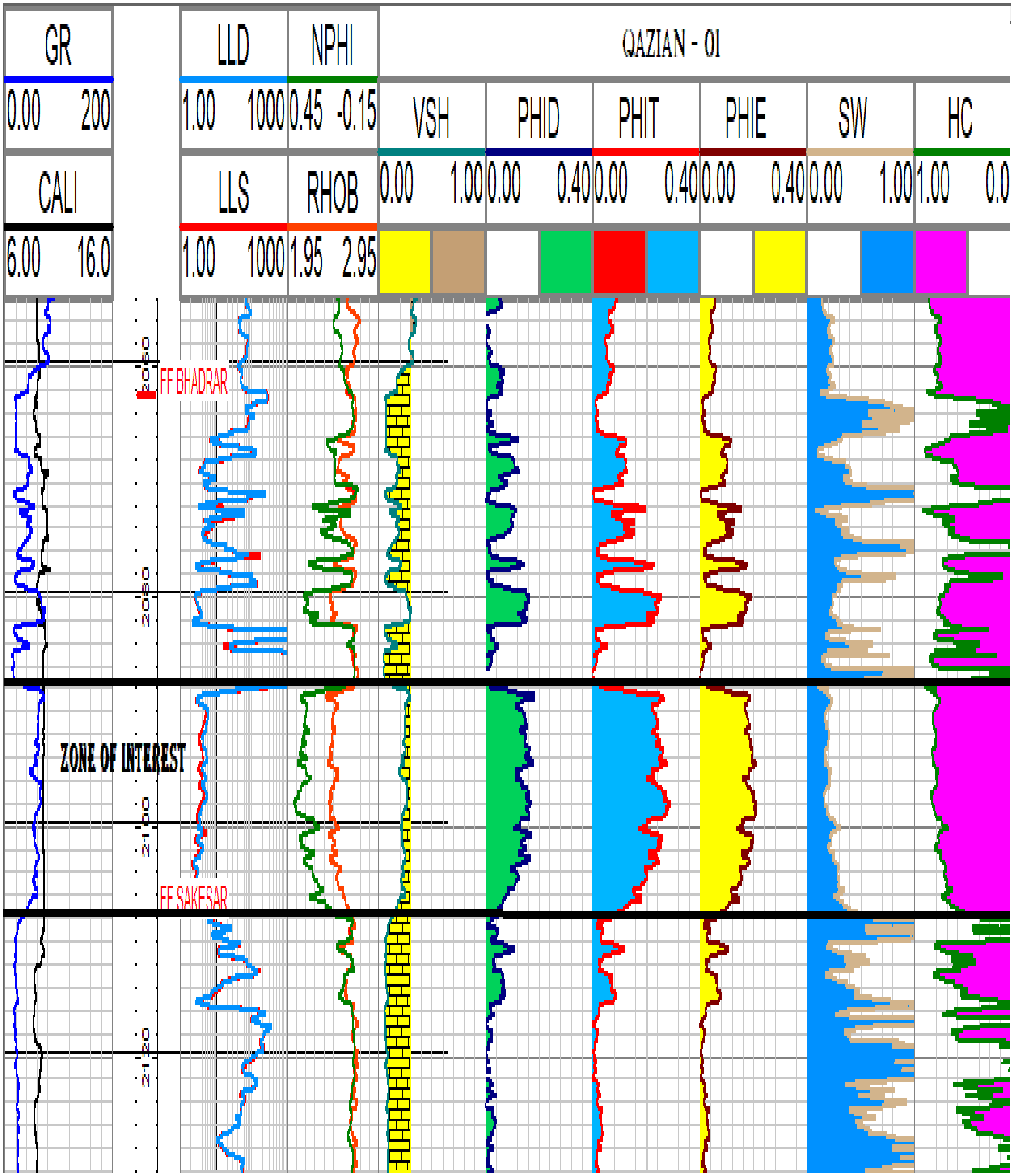

Fig 4.2 Petrophysical Analysis

4.4 Defining zone of interest

The zones of interest is marked on the basis of appreciable effective porosity, hydrocarbon saturation, less volume of shale and water saturation. The zones of interest which are marked are listed in the Table 4.1

Zones	Starting depths (m)	Ending depths(m)
Chorgali	2088 m	2110 m

Table 4.1: Calculation of water saturation in zone of interest.

4.5 Results

Volume of shale	Porosity	Water saturation	Hydrocarbon potential
43.7%	19.6%	39.5%	60.4%

Table 4.2 Results calculated by Petrophysics

60% of hydrocarbon potential is calculated from the average values of hydrocarbon saturation in the zone of interest. i.e Chorgali (2088m to 2110m).

Chapter 5

Facies

Analysis

5.1 INTRODUCTION

Geologically facies is a rock body which having some specific characteristics which distinguish it from the other (Ravia et al., 2010).

Generally the facies is distinctive rock unit that form under certain condition of the sedimentation that reveals the environmental process. The differentiation between the shale and sand has been constantly challenged for the geoscientist. In this process the key challenge is identifying the facies, from logging and core data, and degree to which the shale content effect the reservoir properties. This gives the main indication about the productive zone in the reservoir (Kurniawan, 3005).This problem leads us towards the cross plots which provides us the relationship between the reservoir properties and log response (Naji et al., 2010).

These facies are related to the certain depositional environment. Basically the depositional environment is specific type of place where the facies are deposited. Such as the Glaciers. Lakes, Abyssal plain, Sea bottom. Stream, Delta etc. The different types of the sedimentary environment are shown in the below figure 5.1.

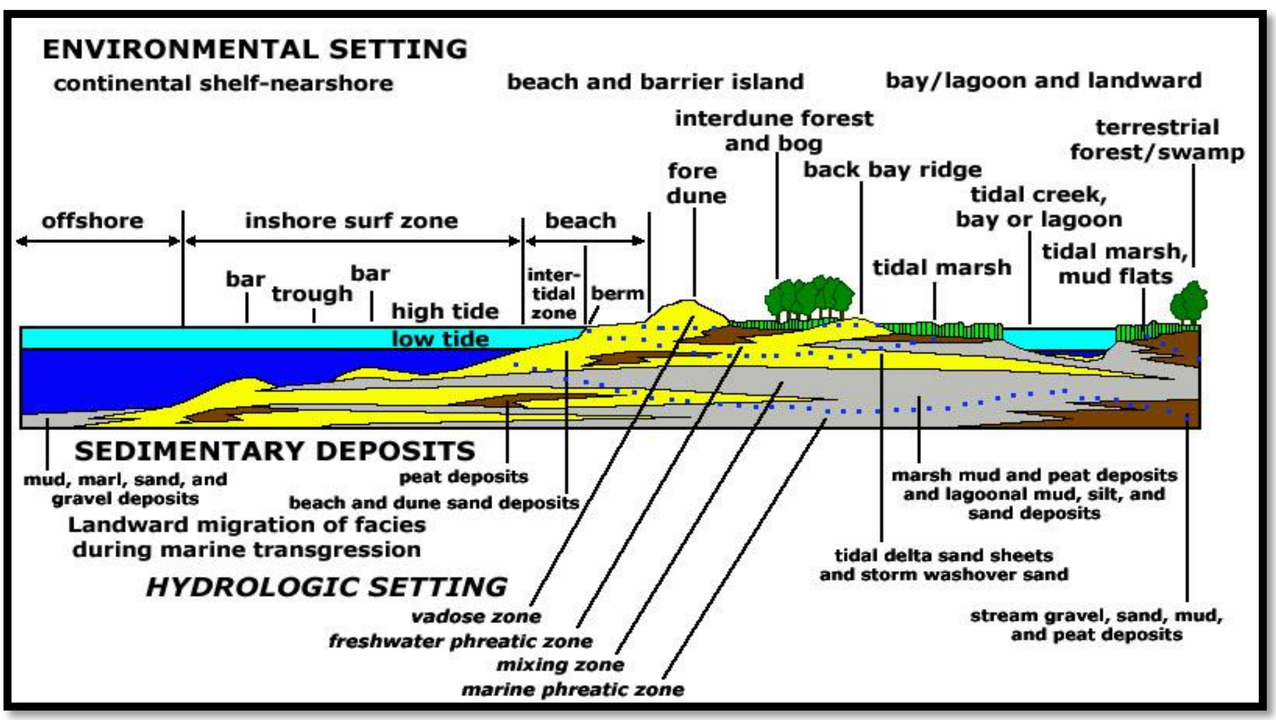

Figure 5.1 Facies deposited in different environment

5.2 Sedimentary facies.

The sedimentary facies can be differentiated from each other on the basics of the change in the depositional environment.

Sedimentary facies are bodies of sediment recognizably different from adjacent sediment deposited in a different depositional environment, as shown in figure given below. The sedimentary environment is the specific depositional setting of a particular sedimentary rock and is unique in terms of physical, chemical, and biological characteristics. The physical features of a sedimentary environment include water depth and the velocity and persistence of currents.

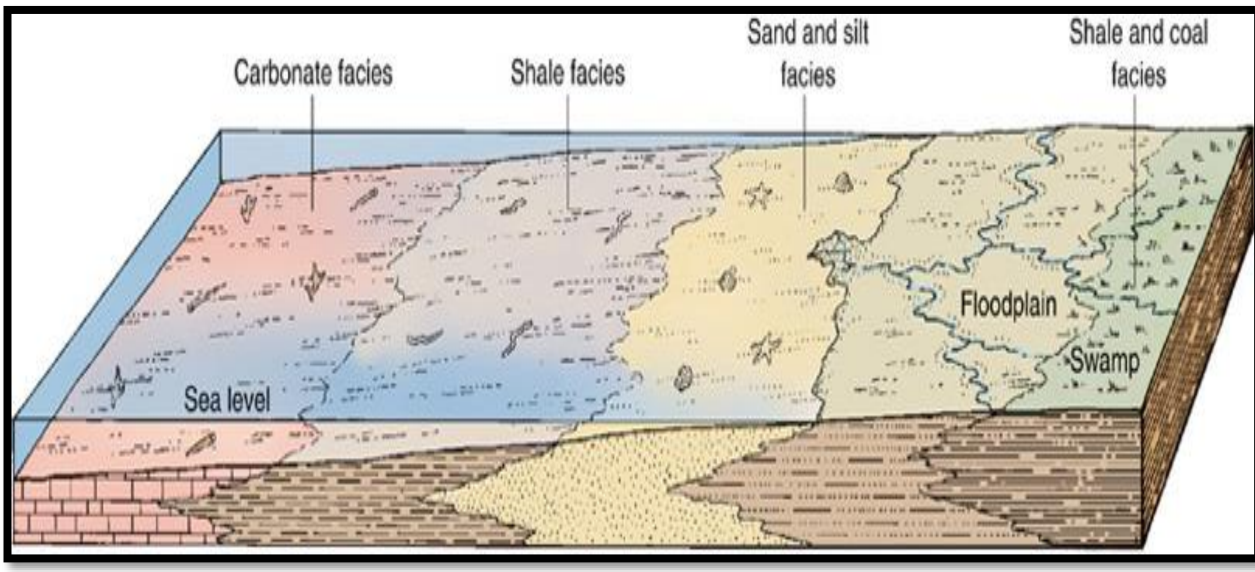

Fig 5.2 Deposition of sedimentary facies

5.3 Facies analysis of Chorgali

The facies modeling is performed by plotting different logs .Which log is to be run depend upon objectives of facies modeling.

Cross plot of LLD and RHOB

The figure 5.3 shows the Cross plot of LLD and RHOB. Since resistivity and density of limestone is higher than shale so limestone facies are marked at higher values as shown in figure 5.3. Since density of shale is highly variable in case concentration of organic contents is lower in shale the density of limestone and shale can overlap so Gamma log is used as reference log for further separation of facies. The light blue color shows the shale while the yellow color shows the limestone.

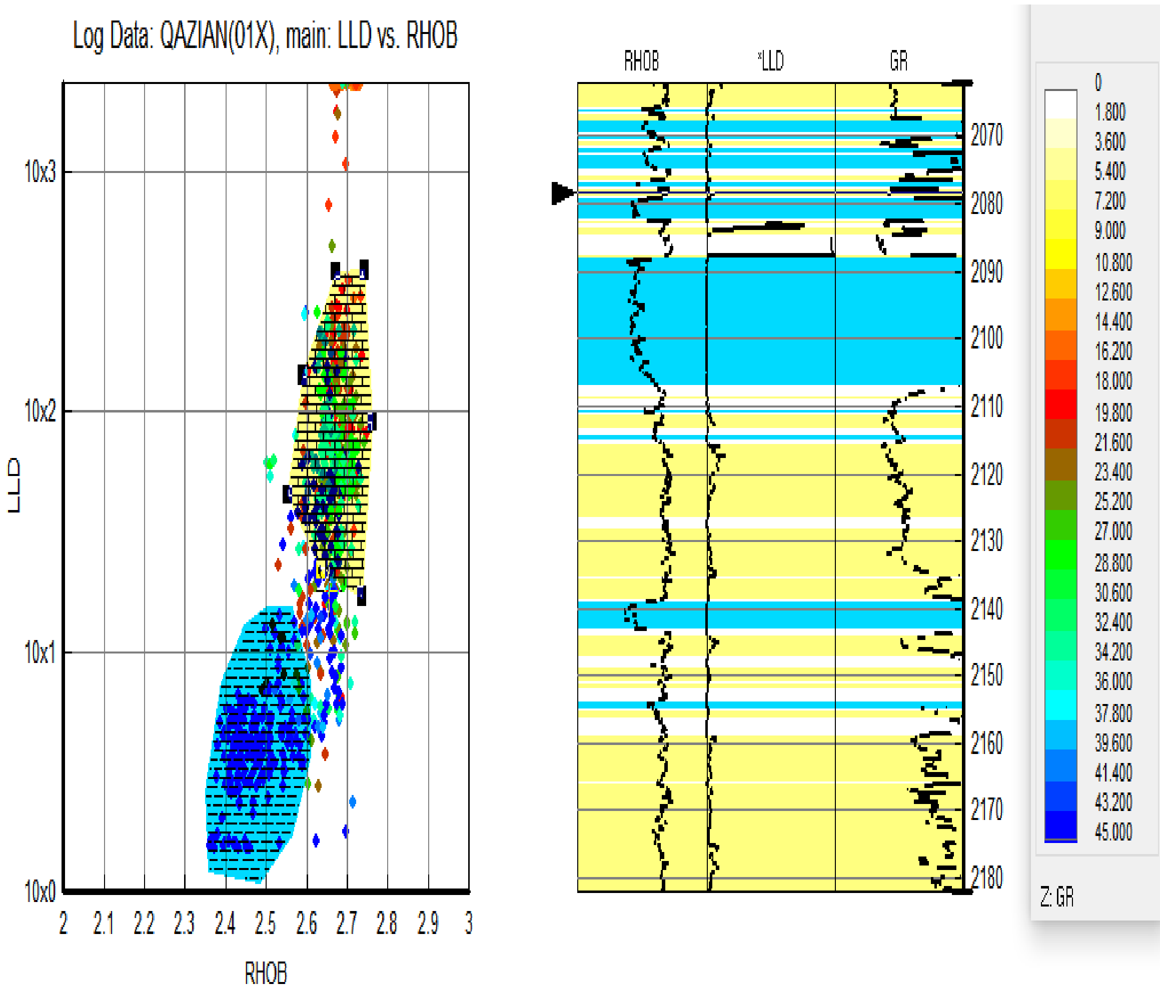

Figure 5.3 Cross plot of LLD and RHOB

GR, NPHI-E and RHOC cross plot

There is an direct relation between NPHI and shale. Greater the value of NPHI shows high value of shale. Limestone has high value of RHOB and low value NPHI. Shale has low value of RHOB and high value of NPHI. In Fig 5.4 NPHI is plotted along y-axis and RHOB is plotted along x-axis. Gamma log is used as reference log for further separation of facies. Yellow to brown colors shows the limestone and green to blue colors shows the shale.

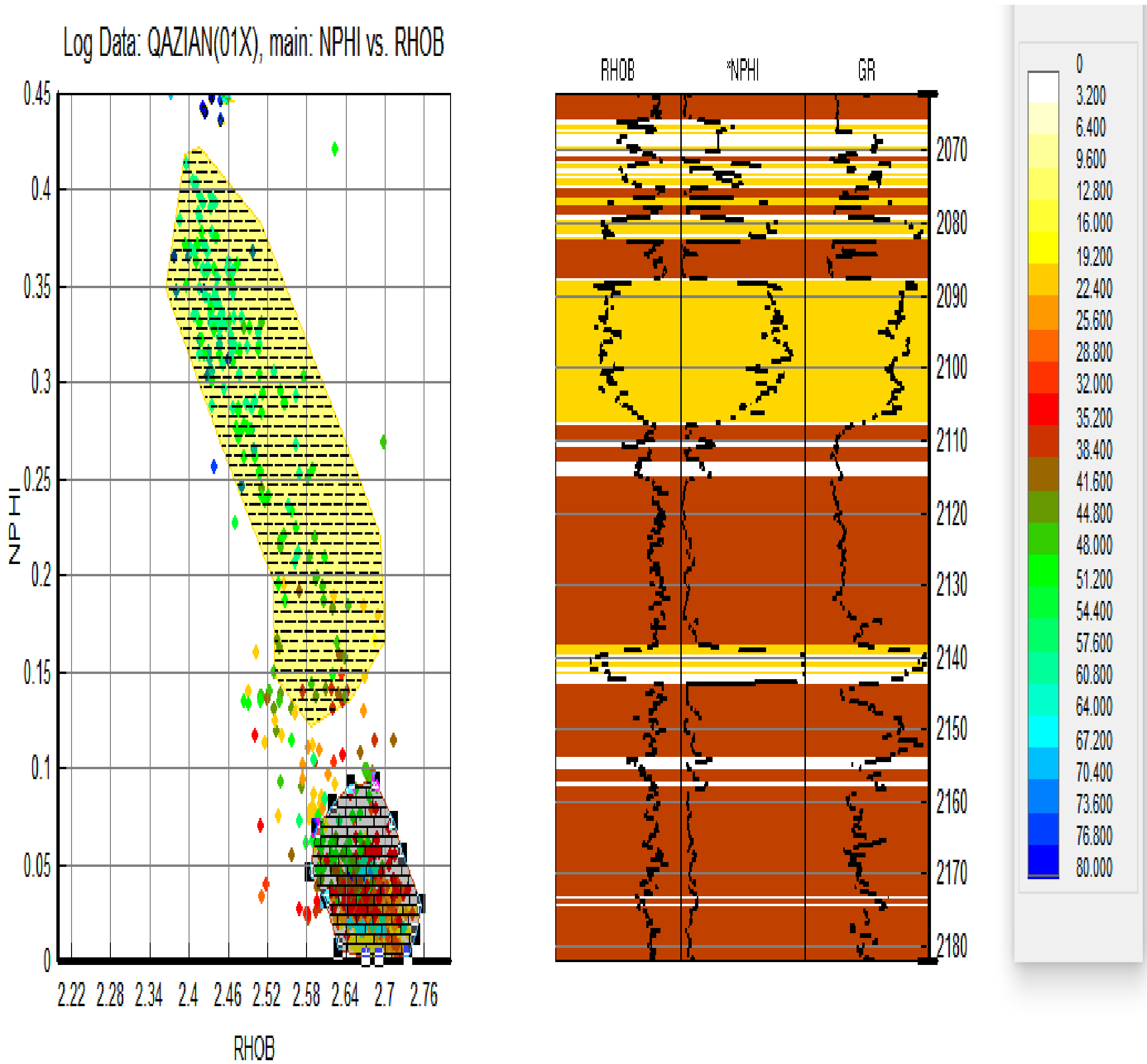

Figure 5.4NPHI, RHOB and GR at Qazian-01

CONCLUSIONS

- Seismic interpretation results have identified pop-up anticline structures in the area of study which are favorable structures for the accumulation of hydrocarbons.
- Missakaswal area lies in a compressional regime characterized by thrust faulting and anticline structures
- There is repetition of Eocene strata in Missakaswal area due to over thrusting. This is also evident on the seismic section. However due to unavailability of complete log data and lack of control on the seismic data, the repeated portion of Eocene age is not marked and confirmed.
- Reflectors of two formations Chorgali and Khewra sandstone were marked on seismic section, with the help of synthetic seismogram of Qazian-01 well. Time and depth contour maps show the presence of pop-up anticline structures in study area.
- An anticlinal pop up structure is marked on the seismic sections with two thrust faults F1 and F2 dipping towards each other from east and west.
- Time and depth contour maps show the presence of pop-up anticline structures in study area.
- The petrophysical interpretation of well Qazain-01 leads us to probable zones for hydrocarbon extraction in chorgali formation from (2088 m to 2110 m) which show the 60% of hydrocarbon in zone of interest.
- Due to limitation of data control in seismic only confirm the interpretation at some locations but not give any reliable location to identify hydrocarbons.
- The pop up structure formed can be a good reservoir if the source formations are present.
- For the confirmation of reservoir lithology Facies analysis were done of Qazain-01 well which reveals the result limestone as the reservoir lithology.
- The Chorgali formation marked on the seismic section are proved to be the good reservoirs.

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