2-D STRUCTURAL INTERPRETATION OF SEISMIC LINES AND SEISMIC ATTRIBUTE ANALYSIS OF DINA BLOCK, EASTERN POTWAR, PAKISTAN

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A thesis submitted to Bahria University, Islamabad in partial fulfillment of the requirement for the degree of M.S in Geophysics

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ABSTRACT

This research is based on the 2D-seismic reflection data. The data is acquired from the area of Dina, Eastern Potwar Northern Indus Basin of Pakistan. This data was provided by the LMK Resources by the prior permission of Directorate General of Petroleum Concession (DGPC). Five seismic sections having line numbers along with base map are 942-DNA-71, 942-DNA-72, 942-DNA-56, 942-DNA-66, and 962-DNA-112. Out of these five seismic lines four are the dip lines and line 942-DNA-69 is a strike line. Root mean square and interval velocities are also provided with the seismic section at selected CDP'S. Velocities are used for the calculation of average velocities to convert the given time sections into depth sections. Due to their prominent reflection on the seismic sections four reflectors were marked. The time contour structural map for each reflector had drawn and by using velocity and one way travel time depth contour map of probable reservoir had also drawn. Thrust faults are present in the area and associated popup and positive flower structures had been observed. Seismic attributes maps are generated to understand further the presence of hydrocarbon. The seismic attributes value at Chorgali Formation indicates the absence of hydrocarbon but confirms the presence of lime stone.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Hydrocarbons plays very important role in the economics of any country. Geoscientists are applying different methods and trying since long time for hydrocarbons exploration. Seismic methods are the most common and reliable in the hydrocarbon exploration.

The Kohat-Potwar depression is part of Indus basin; (Fig. 1.1) extra continental downward basins belongs to the type of basin system which produces 48% of the world's known hydrocarbon resources. The Potwar basin comprises of many features favorable for hydrocarbon accumulations. Area is part of continental margin, thick deposits of sedimentary rocks, producing the petroleum system, including potential source, reservoir and cap rock (Riva, 1983).

1.2 Introduction of study area

Eastern Potwar is a complex structure zone with the thrust belt due to the compressional regime in the region. Shahab structure lies in Jhelum district of the Punjab province. It is about 15 km NE of Sohawa and 6.5 km of Missa Kaswal field. Dina concession is located in between 33° 23' 45" N, 73° 22' 30" E and 32° 50' 00"N, 73° 25' 30"E. Total area of this concession is 889.25 Km^2.

At the same time this part of the Potwar having abundant number of active structural features both surface and subsurface. Some important places like Islamabad, Rawalpindi, and Meyal are also situated near the area.

1.3 Previous seismic study

OGDCL Crew SP-2 acquired seismic data in 1994. 2D structural interpretation was performed on this data, due to this interpretation TWT time contour maps were generated. Quality of the data varied from fair to good. Shahab well was drilled in 1995 as a test well. The well was suspended on June 30, 1995. The projected depth was 4100 m.

The purpose of the study was to locate the zone of importance at Eastern-Potwar area (Fig. 1.1) and to develop the understanding of sub-surface features in the petroleum development.

The base map (Fig. 4.1) representing the study area. After seismic interpretation time contour maps and depth contour maps will be generate. To check the accuracy and confirmation, time and depth contour map results will be correlated with the attribute analysis.

1.4 Objective of the research

The main objective is to study the geology, understand the tectonics, structural trends and define the subsurface target seismic horizon in the Dina region. 2D structural interpretation of the given data to find out further drillable locations.

This research will include generation of time and depth contour maps on the marked horizons and to identify and analyses prospective structure that may be present in the area. Seismic attributes analysis will help in order to make the assessment for possibility of hydrocarbon present.

1.5 Data

For the research 5 seismic lines (Fig. 4.1) were given by Landmark Resources (LMKR) with the approval from the Directorate General of Petroleum Concession, (DGPC).

Seismic 2D line

SegY

(1) 942-DNA-71 Dip line

(2) 942-DNA-72 Dip line

(3) 942-DNA-56 Dip line

(4) 942-DNA-66 Dip line

(5) 962-DNA-112 Strike line

Supporting data

Base map

Figure 1.1. Map of Pakistan and marked Potwar area (Akhtar, et al.,, in press).

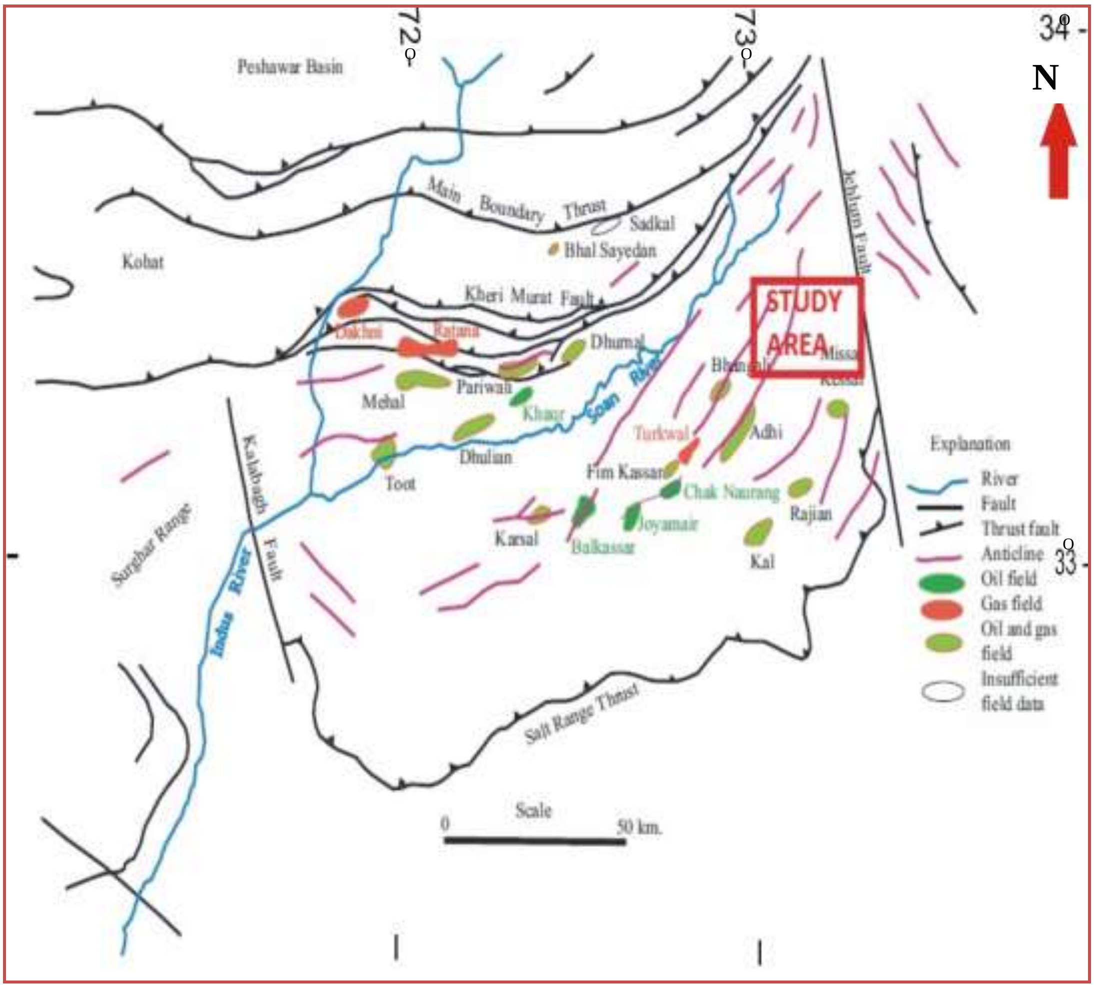

Figure 1.2. Generalized oil and gas fields and structure map of Kohat-Potwar region. Study area is also marked (Kazmi and Rana, 1982; Khan et al., 1986; Law et al., 1998; Petroconsultants, 1996).

CHAPTER 2

GEOLOGY

2.1 General geology of the region

The Potwar Basin is located in the western foothills of the Himalayas in northern part of Pakistan. It comprises of Potwar Plateau, Jhelum Plain and Salt Ranges (Aamir and Mass, 2006). In Indo-Eurasian collision western region of the collision plate affected more severely as compared to the eastern part, because of which uneven structures are produces. The result of continent-continent collision of the Indo-Eurasian plates, northern Pakistan has been deformed tectonically. Horizontal shortening, high mountains and vertical thickening of crustal rocks characterize the lithospheric convergence deformation within regions (Paracha, 2000).

Due to the collision, a SE to NW rotational movement of the continent started which resulted in a trend of thrust tectonics in the Potwar region (Paracha, 2000).The northern Pakistan area having difficult geological attributes, due to several thrust faults asymmetrical structures which may have been formed. It is a complex tilted plateau. The previous geophysical and geological studies have indicated that area had a number thrust faulting systems and salt affected systems which are formed due to compressional tectonics. MBT bounded the area is in the north, Jhelum strike slip fault in the east, SRT in south and Kalabagh strike slip fault in west.

The youngest mountain chains in the world are Himalayan, created due to collision between southern part of Eurasian plate and northern part of Indian plate. Along the Main Karakoram Thrust (MKT) the southern Asian plate is composed of deformed sedimentary, meta sedimentary and igneous rocks emplaced over the rocks of the Kohistan Island Arc (KIA). Along the Main Mantle Thrust (MMT), The Kohistan Island Arc rocks are thrust over the northern edge of the Indian plate. In the south northern Indian deformed foreland rocks are marked by Main Boundary Thrust (MBT) (Fig. 2.1). The Main Boundary Thrust system contains highly deformed Pre-Cambrian to Cenozoic sedimentary rocks, which become younger southward.

2.2 General tectonics of the region

The common plays in the Potwar area are Triangle zone. In the southern Potwar platform zone (SPPZ) the Joya Mair triangle zone and northern Potwar deformed zone (NPDZ) the Khairi Murat thrust-Dhurnal back thrust triangle zone.

The geometry of Domeli-Dil Jabba triangle zone which is the result of collision between Indian and Eurasian plates, the phases of thrust and back thrust in the eastern Potwar are the result of a NW-SE Himalayan compression. The result of regionally extensive convergent thrust sheets is the eastern edge of Potwar (Aamir and Mass, 2006). In the Potwar, tight and occasionally overturned anticlines separated by wide synclines are formed by south verging thrusting. The major thrust faults dip to the north which has created the popup structures. On the regional plane of the decollement, the faults detach i.e., Salt Range Formation (Aamir and Mass, 2006).

The eastern Potwar region represents large low-angle detachment faults. Classical imbricate thrusts, triangle zones and popup structures are common. Salt Range, Domeli forward thrusts, Dil Jabba and Domeli back thrusts are largely controlling tectonic framework of the region. The Dil Jabba thrust is a back thrust of the SRT. Both forward thrust (Domeli thrust) and back thrust (Dil Jabba thrust) having same intensity. In the NE the Domeli thrust is dominant, whereas in the SW the Dil Jabba thrust is dominant (Aamir and Mass, 2006).

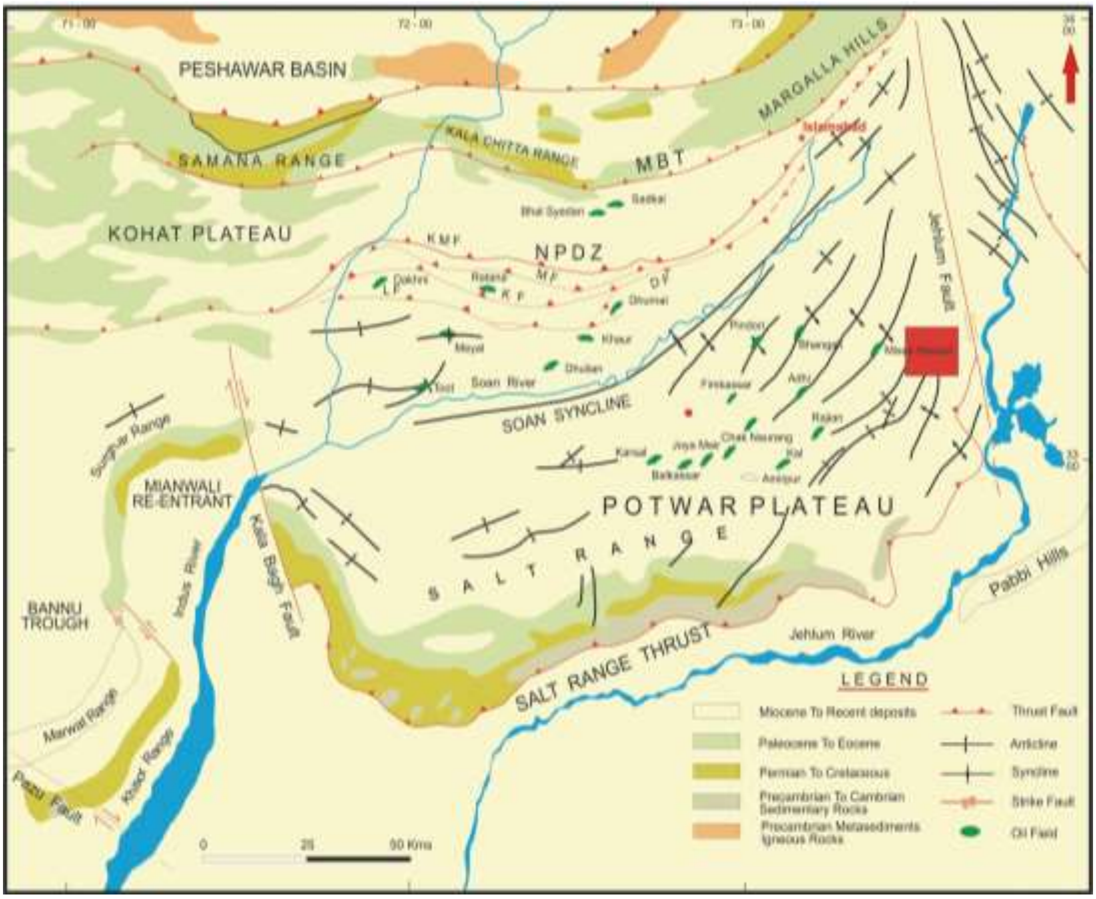

Figure 2.1. Major Structure present in the Potwar Basin and marked study area (Khan et al., 1986).

CHAPTER 3

STRATIGRAPHY AND PETROLEUM GEOLOGY

3.1 Stratigraphy of potwar region

Stratigraphicaly Potwar region is divided into three sequences which are bounded by unconformities. These unconformities are Ordovician to Carboniferous, Mesozoic to Late Permian, and Oligocene. Due to complex thrusting these unconformities are very difficult to identify in the seismic profiles. The Potwar sub-basin is filled with thick evaporite deposits of infra-Cambrian, Overlain by platform deposits of Cambrian age. During the Himalayan Orogeny due to intense tectonic activity in Pliocene to middle Pleistocene time whole section has been severely deformed (Aamir and Mass, 2006).

The Infra-Cambrian Salt Range Formation (SRF) is the oldest formation in this area, which is composed of halite with subordinate marl, shales and dolomite. The SRF is best developed in the eastern salt range (Aamir and Mass, 2006). On the basement of Precambrian, salt lies unconformably. From Cambrian to Eocene the overlying platform sequence having major unconformities at the base of Permian and Paleocene. Uplifting of the Potwar region during Ordovician to Carboniferous resulted in no sediments deposition in the basin (Aamir and Mass, 2006).

The complete absence of sedimentary succession of Mesozoic is the second major change in sedimentary pattern throughout the eastern Potwar region. In Mesozoic age, central Potwar was the area where depocenter was located (Aamir and Mass, 2006). Third major unconformity where the whole Oligocene sedimentary is missing is between the platform sequence and overlying molasse section (Aamir and Mass, 2006). Whereas crosssection showing structures through the Potwar Plateau are clearly define in Figure 3.1.

3.2 Lithological description of formation of study area

Lithological description of the marked probably horizons of the study area are given below.

3.2.1 Cambrian section

(i) Khewra Sandstone

The type locality is near Khewra Town in Khewra Gorge, Salt Range. The upper contact with the Kussak Formation is disconformable and is marked by a thin conglomerate bed and the lower contact is transitional with the underlying Salt Range Formation. The lithology consists of a maroon shale group as a lower unit and purple to brick red sandstone as a middle unit. The upper unit has light to red and yellowish white sandstone (Shah, 1977).

(ii) Kussak Formation

The type locality lies in the eastern part of the Salt Range near Kussak Fort. The contact of the Kussak Formation with the underlying Khewra Sandstone is disconformable and its upper contact is conformable with Jutana Formation. The formation having interbedded silty shale and quartzose sandstones with sandy dolomite (Petroconsultant, 1996).

3.2.2 Paleocene section

(i) Patala Formation

The Patala Formation is composed of shale and marl with subordinate sandstone and limestone. It has a thickness of 97 m at the Patala Nala. The formation conformably lies above and below the Lockhart Limestone and Nammal Formation (Afzal, 1997).

3.2.3 Eocene section

(i) Chorgali Formation

The Formation is located at Chorgali Pass in the Khairi-Murat ranges. The Chorgali Formation of the Eocene is composed of shale and limestone. It is divided into two groups with the upper part containing mostly limestone and shale and the lower part comprising of only limestone. It is unconformable overlain by Murree Formation and lies conformably above the Sakesar Limestone (Jurgan et al., 1988).

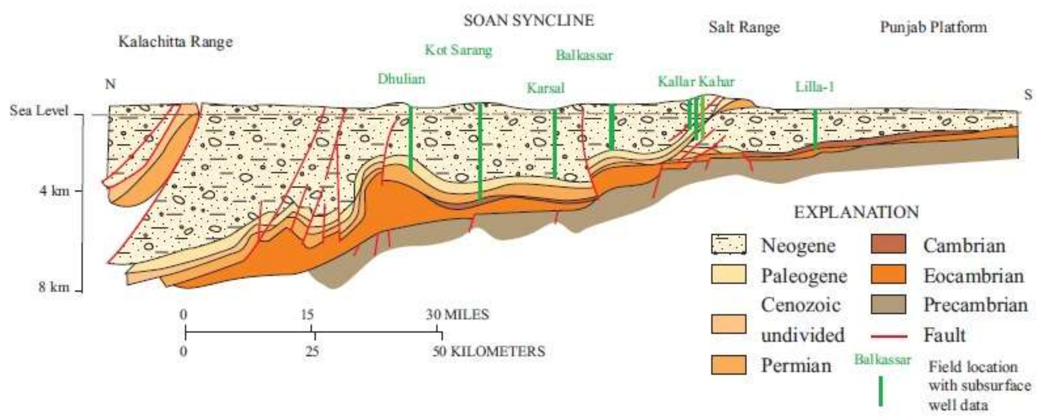

Figure 3.1. Generalized cross section showing structure through the Potwar plateau. from north to south and generalized maturity profile. (Malik et al., 1988).

3.3 Petroleum geology

Petroleum geology includes the study of source rock, reservoir rock and cap rock. Source rocks contain shale and clays which are fine grain rocks. Reservoir rocks contain sandstone, dolomite and fracture limestone whereas cap rocks provide a trapping mechanism that is mainly shale and clay (Jargan et al., 1988)

3.3.1 Source rock

There are several potential source rocks in the Potwar geologic province. These include the Late Proterozoic–Lower Cambrian Salt Range; Permian Wargal, Sardhai, and Chhidru; Paleocene Lockhart; and Eocene Patala Formations (OGDCL, 1996; Quadri and Quadri, 1996).

In Upper Indus Basin Patala shale and Salt Range Formation are consider to the source Formations. These Formations considered being the major producer of hydrocarbons. As the shale and clays have a high porosity in it and are impervious to the flow of liquid.

3.3.2 Reservoir rock

In Potwar region, hydrocarbon has been produced from Kherwa, Kussak, and Jutana in Cambrian, Tobra, Amb, and Wargal Formation of Permian age, Datta

Formation, Lumshiwal Formation of Jurassic age, Khairabad, Lockhart, Patala, and Nammal formation of Paleocene age, Bhadrar, Chorgali, and Margala Hill Limestone of Eocene and Murree in Miocene (Khan at al., 1986. Petroconsultant, 1996). Murree Formation is the youngest reservoir Formation. Reservoir rocks having high permeability and relativity less porosity and allow the fluids to accumulate.

3.3.3 Traps and Seals

Most of discoveries made this region are from overturn faulted anticlines, or popup structural traps. Approximately 5 to 2 Ma the latest trap forming thrust events started (Jaswal et al., 1997). Seals include fault truncations, thick shales, interbedded shales and clays of the Siwalik Group (Miocene and Pliocene).

In the Upper Indus Basin Kussak shale, Nammal shale or Dandot shale, Kohat and Kuldana acts as a cap rocks. Shale and clay also acts as a cap rocks as they have a low porosity and don’t allow hydrocarbon to escape.

3.4.4 Migration

Migration is mainly through faults and fractures associated with plate collision and thrusting, up dip and vertically into adjacent reservoirs. In the Upper Indus Basin migration occurs through the thrust faults present in the area but it should be permeabl

GENERALIZED STRATIGRAPHIC COLUMN OF DINA E.L

(BELOW MOLLASSE)

AGE	FORMATION	DESCRIPTION	SOURCE	RESERVOIR	CAP
EOCENE	CHORGALI	LIMESTONE & MARL			
	SAKESAR	DOLOMITE & LIMESTONE		*	
	NAMMAL	SHALE			
PALEOCENE	PATALA	SHALE & MARL	*		*
	LOCKHART	LIMESTONE & SHALE			
	HANGU	SHALE			
PERMIAN	DANDOT	SHALE & SANDSTONE		*	
	TOBRA	SANDSTONE, SILTSTONE		*	
	JUTANA	DOLODITE		*	
	KUSSAK	SANDSTONE & SHALE		*	*
CAMBRIAN	KHEWRA	SHALE & SANDSTONE		*	
PRE-CAMBRIAN	SALTRANGE	GYPSUM, SALT	*		

Figure 3.2. Generalized stratigraphic column of Dina (OGDCL, 1995).

CHAPTER 4

SEISMIC DATA INTERPRETATION

4.1 Introduction

The basic objective of seismic interpretation is conversion of seismic data into geologic information. The interpretation of seismic data requires the knowing and plotting of geophysical and geological finding into an understandable picture that is more complete and reliable than either source to given alone. Ideally single very experience person should do the interpretation but such persons are very few, at the stage of interpretation collaboration is usually necessary with the geologist.

The interfaces which give rise to reflection events are calculated from arrival times of seismic waves. Interpretation is nothing but transformation of seismic data into a subsurface structural picture by applying corrections, migration and different conversion (Dobrin and Savit, 1988).

Sound waves are used to investigate the subsurface in seismic reflection method. Time sections are produces after marking reflectors on the processed seismic section. Time of every reflector from the given seismic section are noted and then respectively plotted against the shot points or vibroseis point.

4.2 Types of interpretations

There are two types of seismic interpretation i.e., stratigraphic interpretation and structural interpretation.

4.2.1 Structural interpretation

The objective of structural interpretation is the search for structural traps having commercially valuable hydrocarbons. Structural time and depth maps are prepared to display the structural geometry of selected reflection events. Discontinuous reflections clearly indicate faults. Similarly diffractions are indications of faults. Structural contour map can be generated from time using velocity information. Time structural map are very similar to depth contour maps but are subject to misrepresentation associate with vertical or lateral changes.

4.2.2 Stratigraphic interpretation

The search for structural traps containing hydrocarbons is the main objective of stratigraphic analysis. Seismic stratigraphic techniques are used to find out the environmental settings and depositional processes because natively related sedimentary sequences normally consist of continues strata that show dis similarity with sequence laying above and below. It helps to identify formations, unconformities and stratigraphic traps.

4.3 Procedure of seismic interpretation

Procedure of seismic interpretation includes identification of desired reflectors, marking of reflectors, identification of faults, picking of time and then conversion of time section into depth section by using calculated velocities.

4.3.1 Identification of reflector

First step was to pick the most prominent reflector from given seismic line. On the basis of prominent coherency of reflection visible on seismic section Reflectors are marked. Four reflectors are marked R1 (Chorgali), R2 (Patala), R3 (Kussak) and R4 (Khewra).

4.3.2 Identification of faults

On the basis of breaks in the continuity of reflection, faults (F1, F2 and F3) are marked. However, thrust faults are identified on seismic lines.

4.3.3 Time section

It is actually a reproduction of seismic section, it consist of two scales. One is horizontal, which consist of SP's, while second the vertical scale consists of time.

4.3.4 Depth section

An accurate calculation in seismic velocity is very important step in seismic data processing and interpretation. Formula of velocity is as follows.

$$Vav = Vint*Tn-Tn-1 + Vav\ n-i + Tn-1/\ Tn - Tn-1 \qquad \text{Eq 4.1}$$

As,

Vav-------- average velocity

Vint------- instantaneous velocity

The use of appropriate values of velocity and time, the depth of each marked horizons can be easily calculated with formula.

Depth= V*T/2……………………………………………………...…Eq 4.2

As,

V---------Velocity

T--------- Time

In our study work we were given by 5 lines and a 60 fold data was generated in this survey. Where as line names, shooting direction and other information related to it is given below.

4.4 Structural interpretation of given seismic data

For the interpretation 5 seismic lines (Fig. 4.1) were given by Landmark Resources (LMKR) with prior approval from the Directorate General of Petroleum Concession (DGPC). Where as the fallowing figures shows interpreted seismic lines.

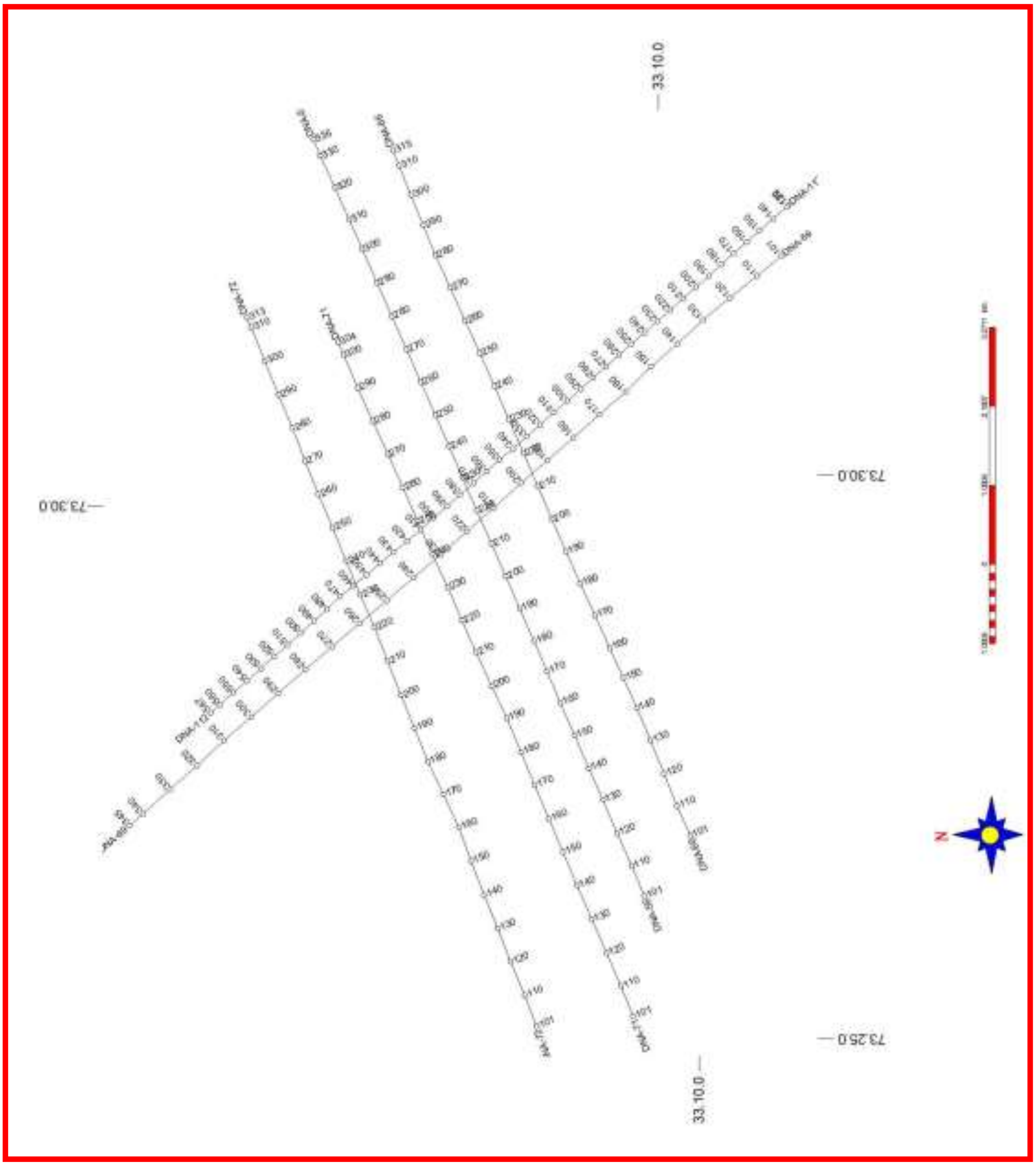

Figure 4.1. Seismic base map of study area.

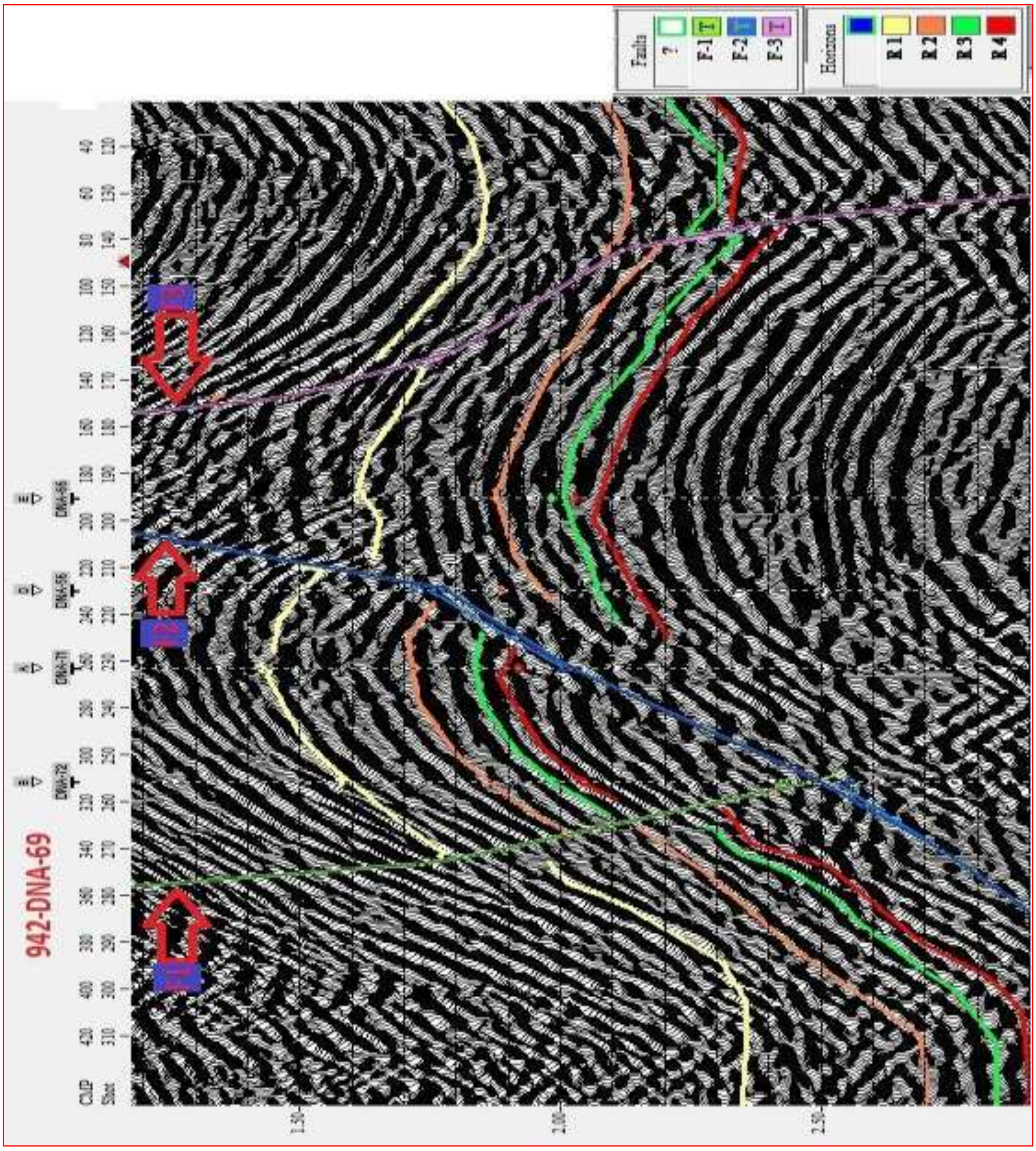

Figure 4.2. Interpreted seismic line 942-DNA-69.

942-DNA-69 is a strike line in NW-SE direction. SP ranging 101-330 and processed in 1994 with 2 ms and 60 fold data. Four reflectors are marked. R1 (Chorgali), R2 (Patala), R3 (Kussak) and R4 (Khewra).

Faults (F1, F2 and F3) are marked on the basis of breaks in the continuity of reflection. F2 and F3 are major faults, on the left F1 is the minor fault which truncates with F2. These thrust faults had been made the thrust and pop-up structure. Pop-up structure shows the highest portion of the area. The structure exists between the F2 and F3 which is the deepest portion of the project and the structure exists between the F1 and F2 is the highest portion of the project.

The throw of the faults decreased from top to bottom. Crossection points of dip lines are also marked on the top the figure. Legend of faults and horizons is given on right bottom corner of the interpreted seismic line.

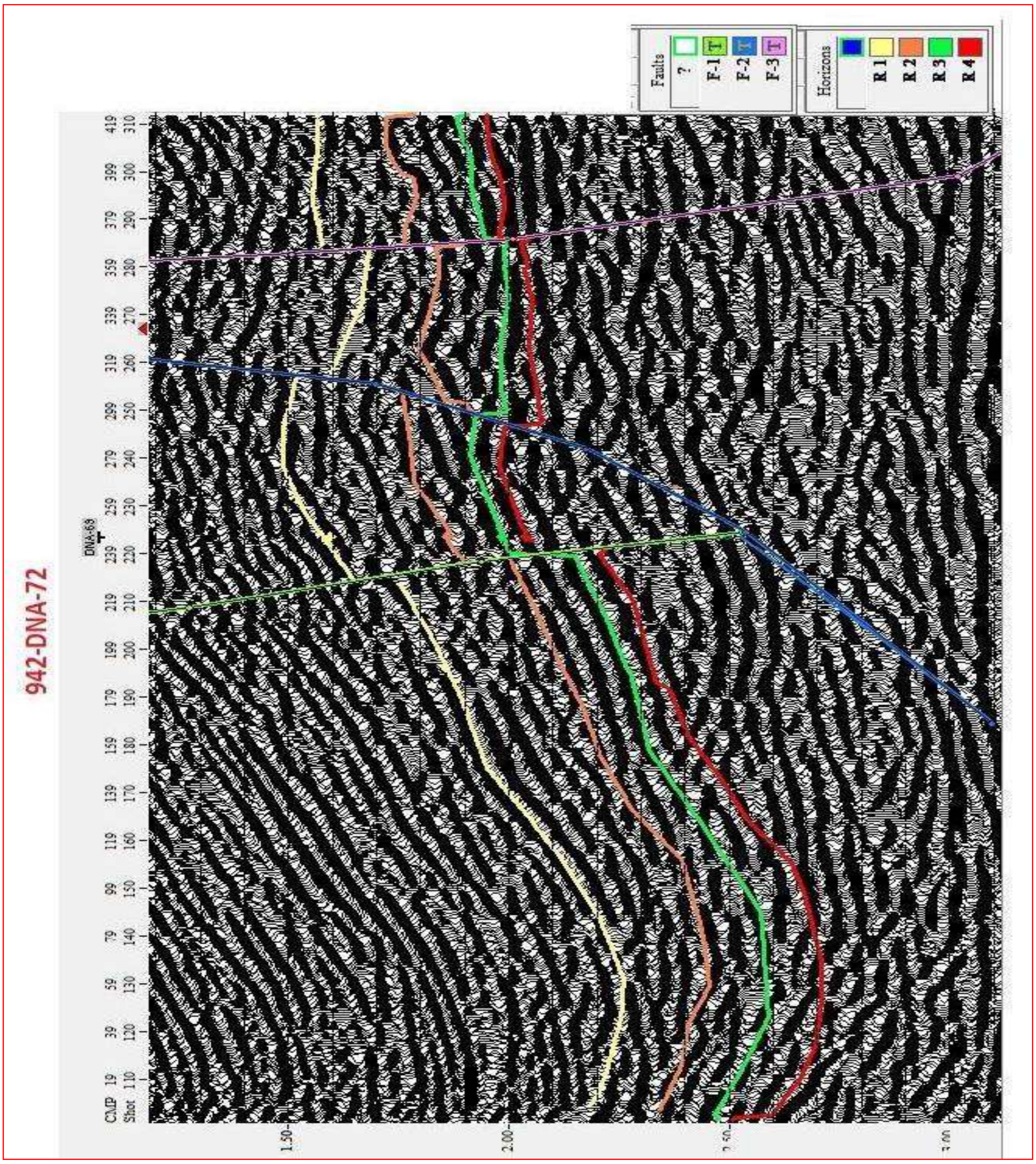

Figure 4.3. Interpreted seismic line 942-DNA-72.

942-DNA-72 is a dip line in NE-SW direction. SP ranging 101-310 and processed in 1994 with 2 ms and 60 fold data. Four reflectors are marked. R1 (Chorgali), R2 (Patala), R3 (Kussak) and R4 (Khewra).

Faults (F1, F2 and F3) are marked on the basis of breaks in the continuity of reflection. F2 and F3 are major faults, on the left F1 is the minor fault which truncates with F2. These thrust faults had been made the thrust and pop-up structure. Pop-up structure shows the highest portion of the area. The structure exists between the F2 and F3 which is the deepest portion of the project and the structure exists between the F1 and F2 is the highest portion of the project.

The throw of the faults decreased from top to bottom. Crossection point of strike line is also marked on the top the figure. Legend of faults and horizons is given on right bottom corner of the interpreted seismic line.

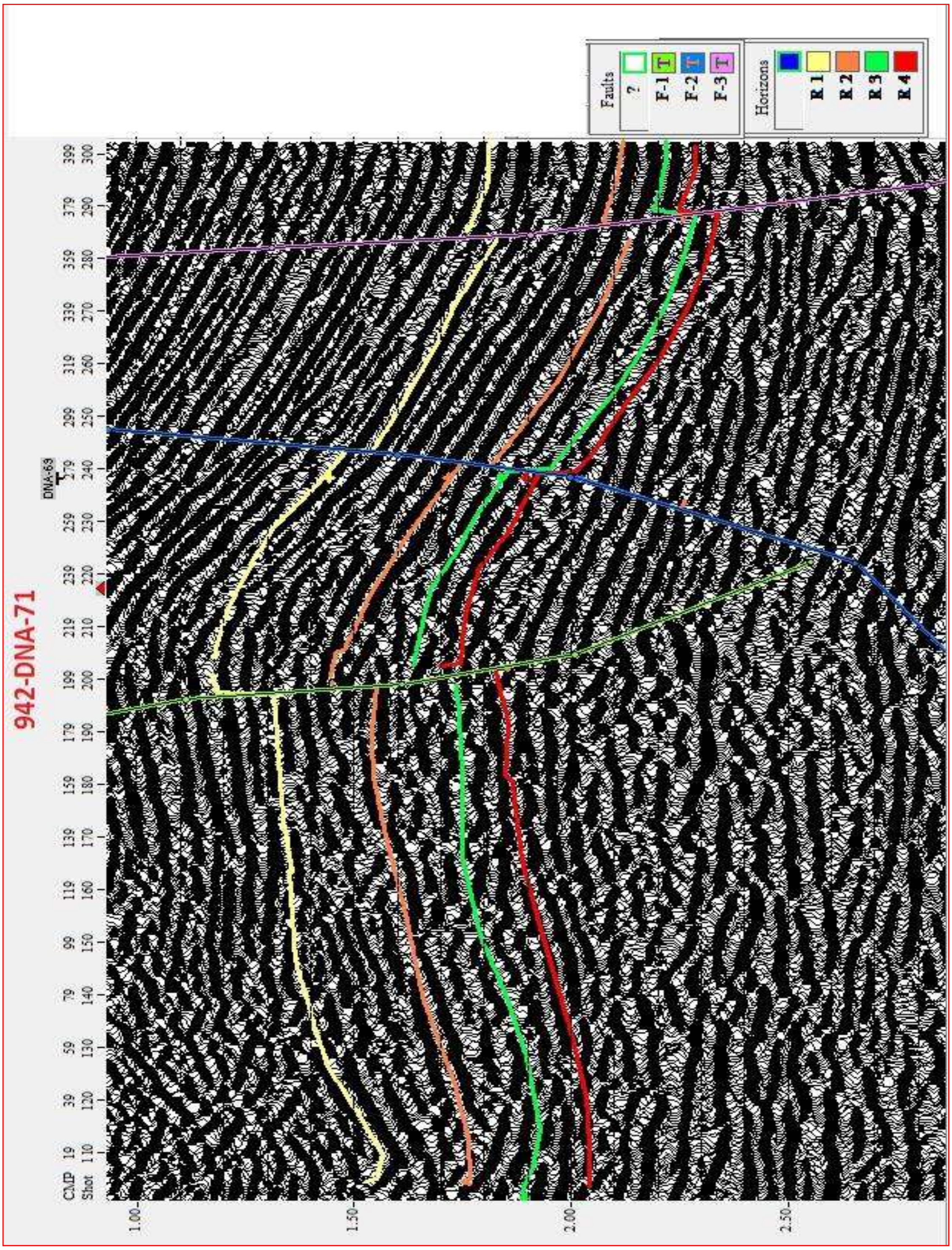

Figure 4.4. Interpreted seismic line 942-DNA-71.

942-DNA-71 is a dip line in NE-SW direction. SP ranging 101-300 and processed in 1994 with 2 ms and 60 fold data. Four reflectors are marked. R1 (Chorgali), R2 (Patala), R3 (Kussak) and R4 (Khewra).

Faults (F1, F2 and F3) are marked on the basis of breaks in the continuity of reflection. F2 and F3 are major faults, on the left F1 is the minor fault which truncates with F2. These thrust faults had been made the thrust and pop-up structure. Pop-up structure shows the highest portion of the area. The structure exists between the F2 and F3 which is the deepest portion of the project and the structure exists between the F1 and F2 is the highest portion of the project.

The throw of the faults decreased from top to bottom. Crossection point of strike line is also marked on the top the figure. Legend of faults and horizons is given on right bottom corner of the interpreted seismic line.

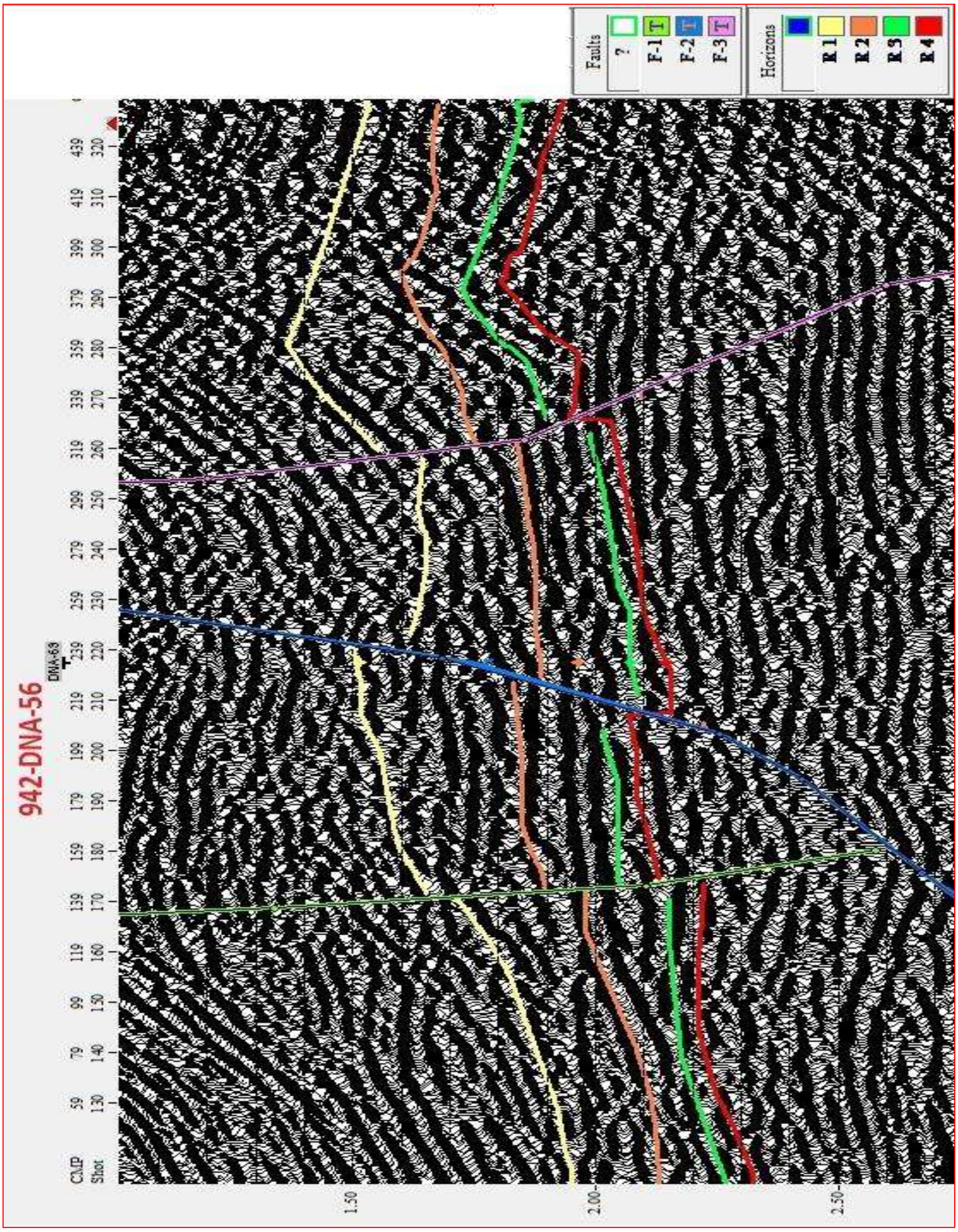

Figure 4.5. Interpreted seismic line 942-DNA-56.

942-DNA-56 is a dip line in NE-SW direction. SP ranging 101-330 and processed in 1994 with 2 ms and 60 fold data. Four reflectors are marked. R1 (Chorgali), R2 (Patala), R3 (Kussak) and R4 (Khewra).

Faults (F1, F2 and F3) are marked on the basis of breaks in the continuity of reflection. F2 and F3 are major faults, on the left F1 is the minor fault which truncates with F2. These thrust faults had been made the thrust and pop-up structure. Pop-up structure shows the highest portion of the area. The structure exists between the F2 and F3 which is the deepest portion of the project and the structure exists between the F1 and F2 is the highest portion of the project.

The throw of the faults decreased from top to bottom. Crossection point of strike line is also marked on the top the figure. Legend of faults and horizons is given on right bottom corner of the interpreted seismic line.

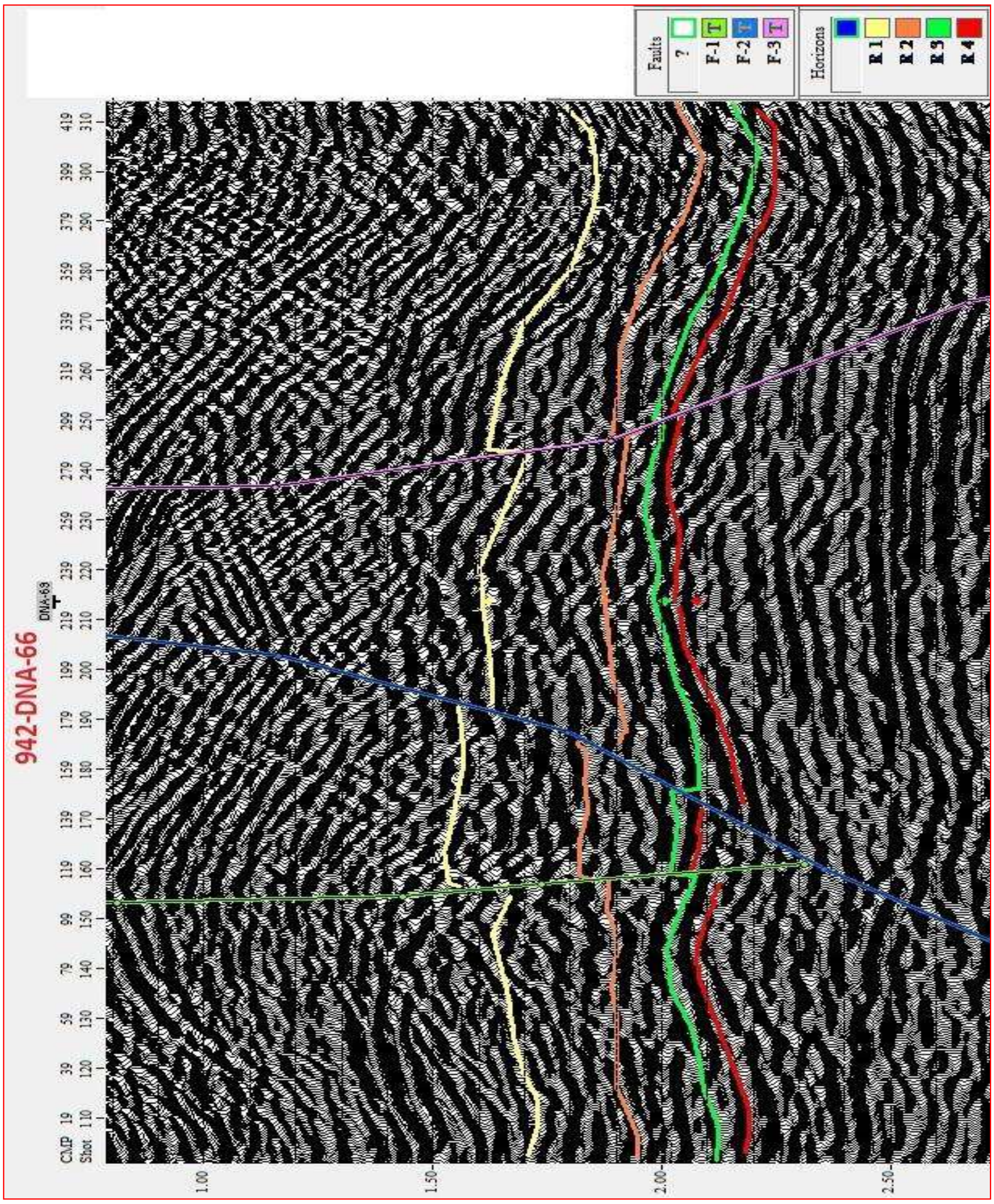

Figure 4.6. Interpreted seismic line 942-DNA-66.

942-DNA-66 is a dip line in NE-SW direction. SP ranging 101-3015 and processed in 1994 with 2 ms and 60 fold data. Four reflectors are marked. R1 (Chorgali), R2 (Patala), R3 (Kussak) and R4 (Khewra).

Faults (F1, F2 and F3) are marked on the basis of breaks in the continuity of reflection. F2 and F3 are major faults, on the left F1 is the minor fault which truncates with F2. These thrust faults had been made the thrust and pop-up structure. Pop-up structure shows the highest portion of the area. The structure exists between the F2 and F3 which is the deepest portion of the project and the structure exists between the F1 and F2 is the highest portion of the project.

The throw of the faults decreased from top to bottom. Crossection point of strike line is also marked on the top the figure. Legend of faults and horizons is given on right bottom corner of the interpreted seismic line.

This Figure 4.7 shows the marked thrust faults in the regional triangle zone. The F1 is minor faults which truncate with F2. The direction of F1 is NW-SE dipping. F2 is the major thrust fault with the direction of NE-SW dipping. F3 thrust fault is also major fault while the orientation of the fault is NW-SE.

In this region there might be some other minor faults that can be interpreted in 3D data but due to poor 2D data quality it’s difficult to interpret.

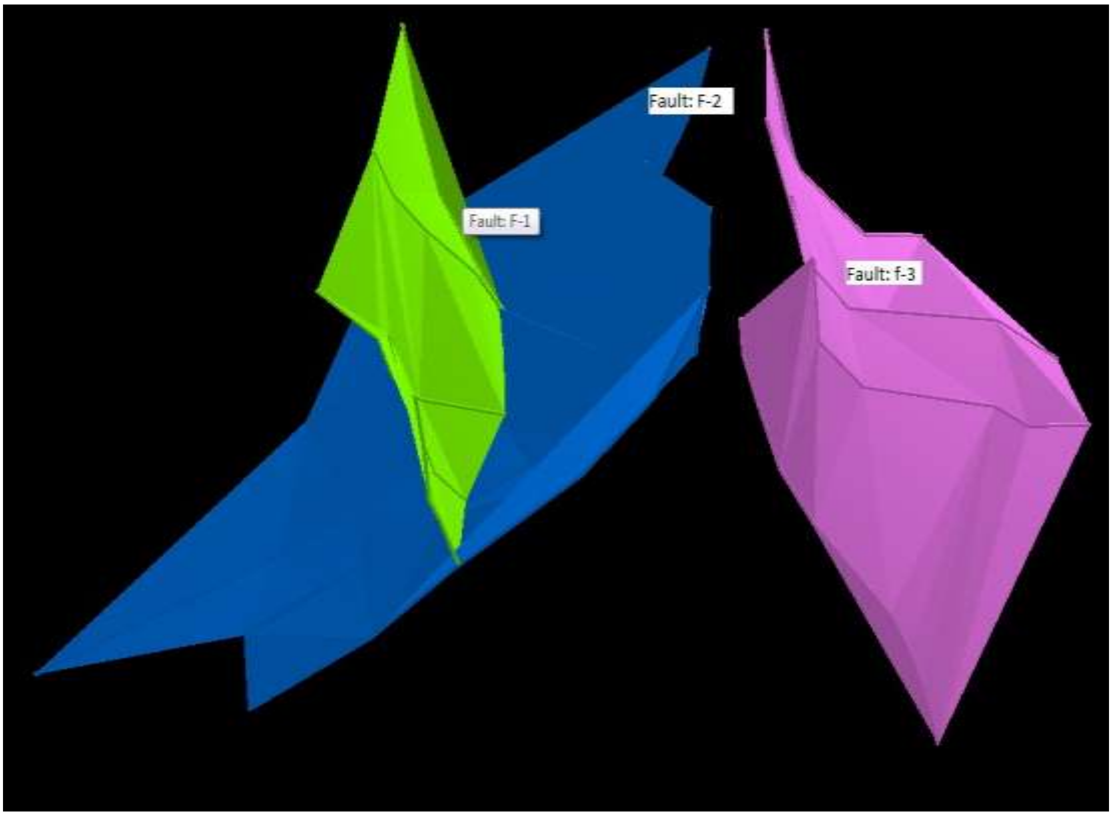

Figure 4.7. 3D fault surfaces model (NE-SW display).

4.5 Time contour maps

Two ways travel time had been noted from seismic sections for the four probable reflectors (Chorgali (R1), Patala (R2), Kussak (R3) and Khewra (R4). Amer every 10 shot points TWT time had been noted from seismic section. Amer that these TWT time had been plotted on the base map and then contoured it with the contour interval of 25 msec. Time contour maps show the probable structures and faults which helped to find the tectonic setting of the area. The time contour maps for four reflectors are shown in Figure 4.8 to Figure 4.11.

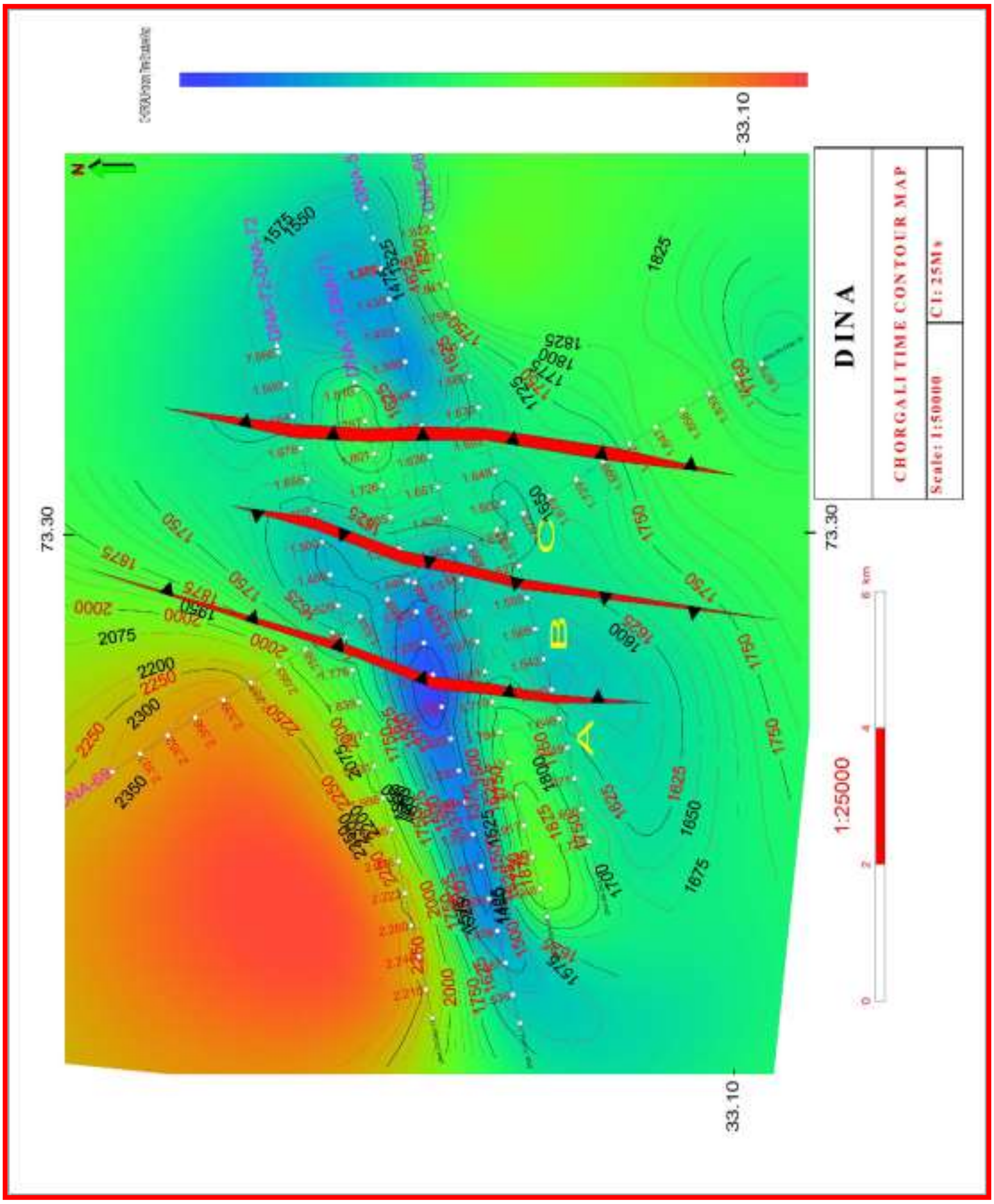

Figure 4.8. Time contour map of Chorgali Formation (R1).

TWT contour map of R1 (Chorgali Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-1 in time contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.8). Highest value of time contour is 1325 msec and shallowest value of time contour is 2350 msec, whereas throw of fault is 10-20 msec.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.8). In this zone pop-up structure is present with is fault bounded. Highest value of time contour is 1350 msec and shallowest value of time contour is 1625 msec, whereas the throw of F1 is 10-20 msec and F2 is 10 msec.

Zone-C

The zone with is in between F1 and F2 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.8). Highest value of time contour is 1650 msec and shallowest value of time contour is 1575msec, whereas the throw of F1 is 10-20msec and F2 is 10msec.

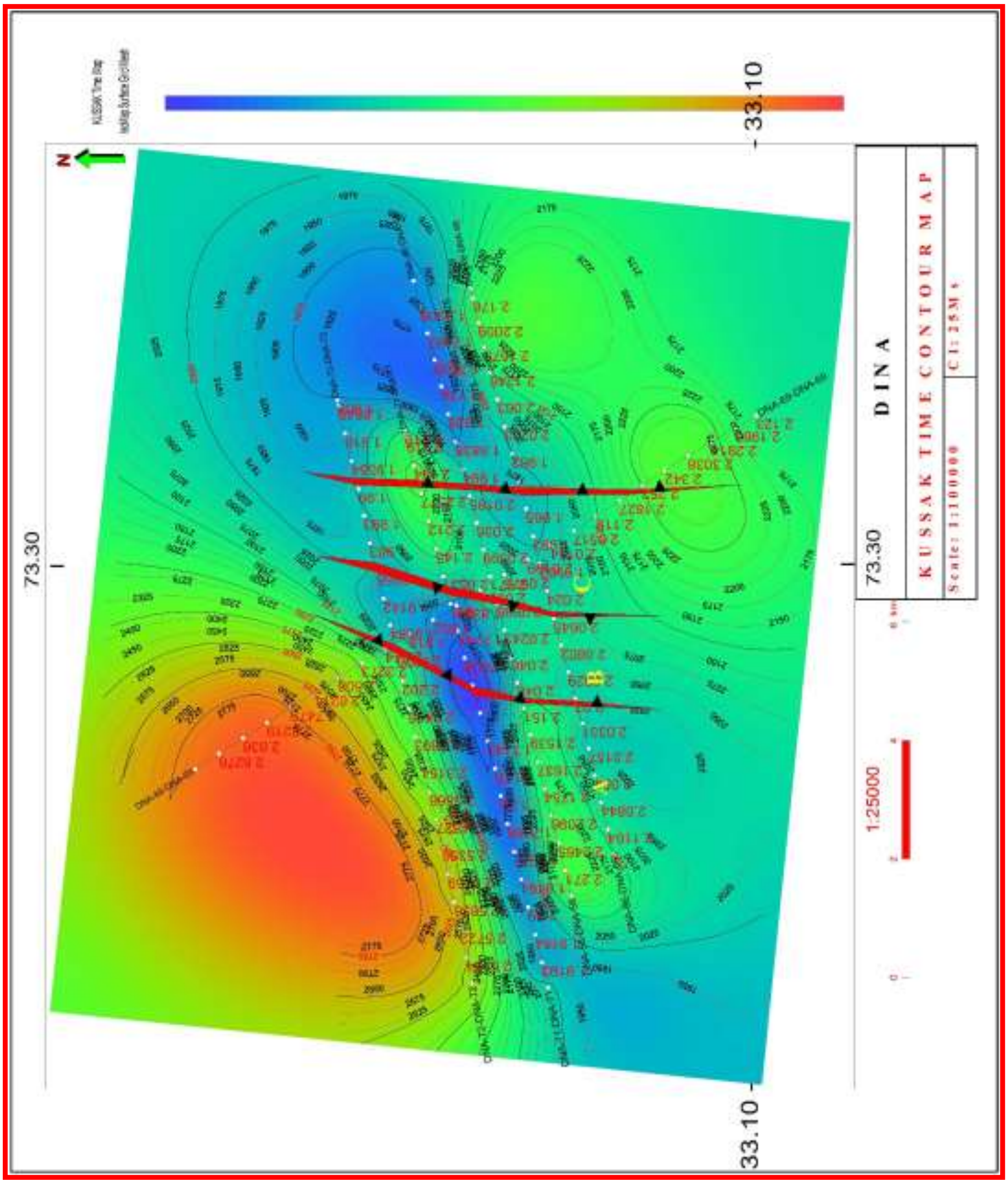

Figure 4.9. Time contour map of Patala Formation (R2).

TWT contour map of R2 (Patala Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-2 in time contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.9). Highest value of time contour is 1550 msec and shallowest value of time contour is 2100 msec, whereas throw of fault is 10-20 msec.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.9). In this zone pop-up structure is present with is fault bounded. Highest value of time contour is 1550 msec and shallowest value of time contour is 2100 msec, whereas the throw of F1 is 10-20 msec and F2 is 10 msec.

Zone-C

The zone with is in between F1 and F2 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.9). Highest value of time contour is 1650 msec and shallowest value of time contour is 2000 msec, whereas the throw of F1 is 10-20msec and F2 is 10 msec.

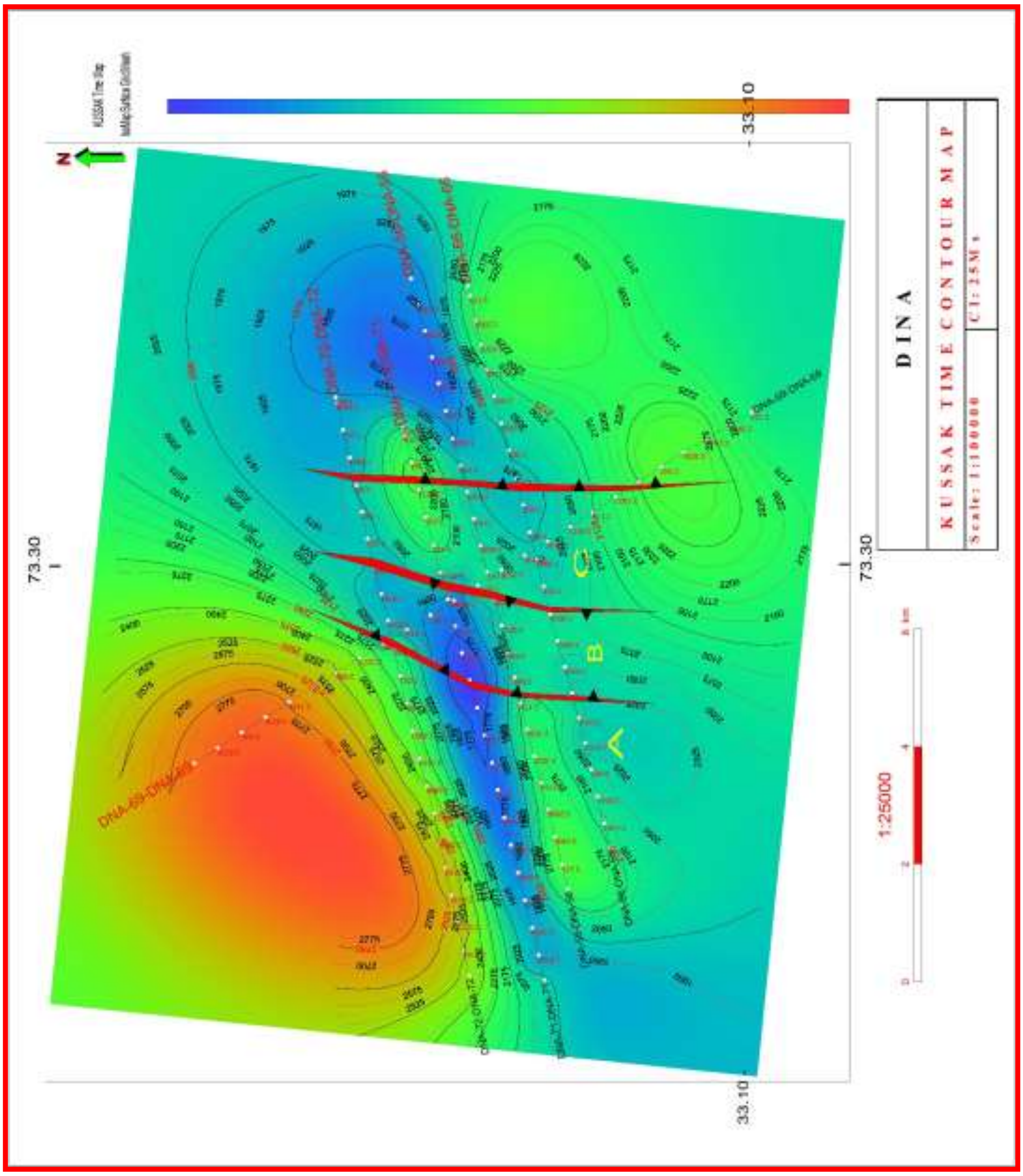

Figure 4.10. Time contour map of Kussak Formation (R3).

TWT contour map of R3 (Kussak Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-4 in time contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.10). Highest value of time contour is 1960 msec and shallowest value of time contour is 2225 msec, whereas throw of fault is 10 msec.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.10). In this zone pop-up structure is present with is fault bounded. Highest value of time contour is 1725 msec and shallowest value of time contour is 2025 msec, whereas the throw of F1 is 10msec and F2 is 10 msec.

Zone-C

The zone with is in between F1 and F2 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.10). Highest value of time contour is 2025 msec and shallowest value of time contour is 2050 msec, whereas the throw of F1 is 10-20msec and F2 is 10 msec.

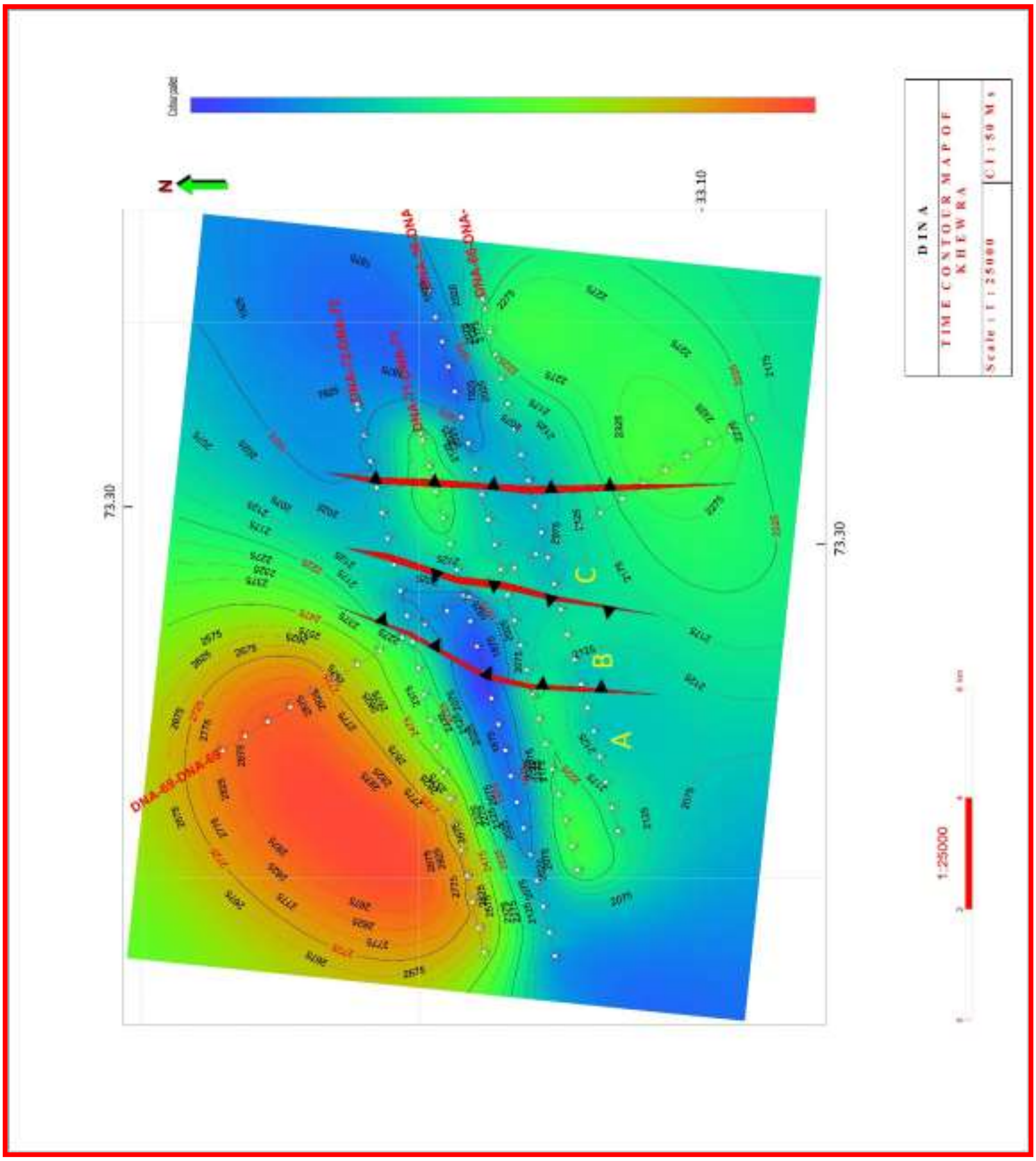

Figure 4.11. Time contour map of Khewra Formation (R4).

TWT contour map of R4 (Khewra Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-4 in time contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.11). Highest value of time contour is 2000 msec and shallowest value of time contour is 2225 msec, whereas throw of fault is 10 msec.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.11). In this zone pop-up structure is present with is fault bounded. Highest value of time contour is 1750 msec and shallowest value of time contour is 2050 msec, whereas the throw of F1 is 6 msec and F2 is 10 msec.

Zone-C

The zone with is in between F1 and F2 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.11). Highest value of time contour is 2040 msec and shallowest value of time contour is 2060 msec, whereas the throw of F1 is 10 msec and F2 is 5 msec.

4.6 Velocity graph

The average velocity graph is formed by plotting the two way travel time and Vinst given in the seismic section. The time was plotted at X-axis and velocity was plotted at the y-axis. A best fit is drawn through the plots of several windows given on the seismic section, from where value of Y was generated. One of the example of time vs. velocity graph and the generated y is shown below in figure 4.12.

These velocities are then converted into the depth by using two way travel time for the Formations encountered in the depth.

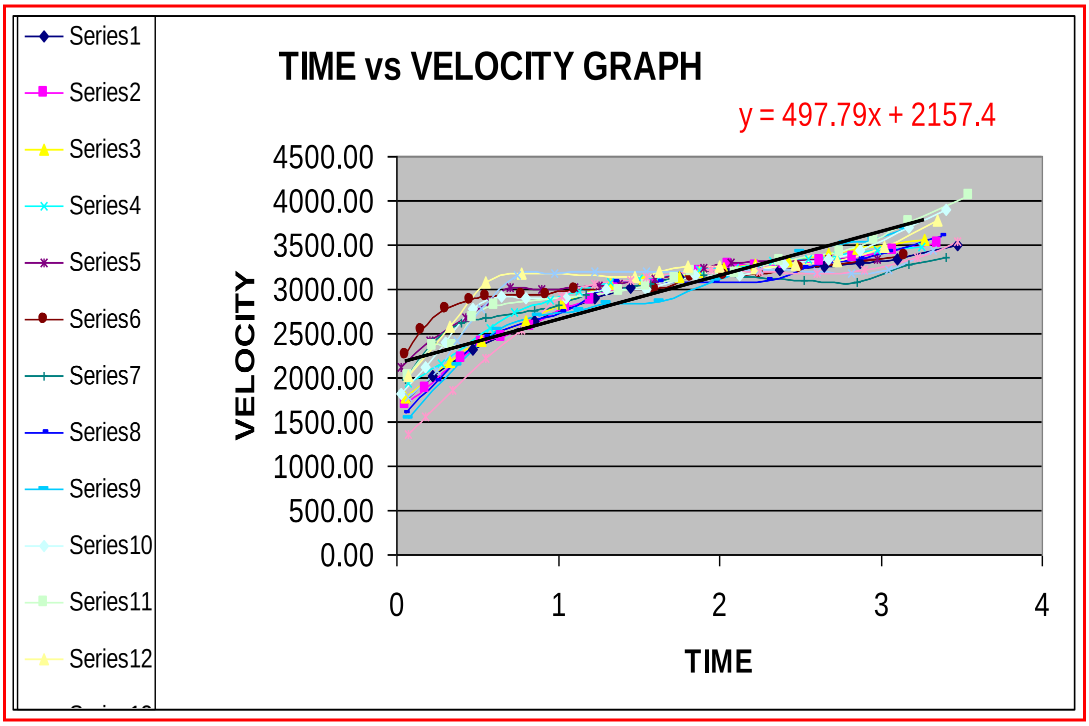

Figure 4.12. Time vs velocity graph on line 942-DNA-69.

4.7 Depth contour map

Depth contour maps are generated by using the generated velocities then these velocities should be multiplied with reflectors time to get depth. Depth values allotted against the S.P on the base map and then go for contouring and mapping. The depth contour maps of the selected reflector are shown in following figures 4.13, 4.14, 4.15 and 4.16.

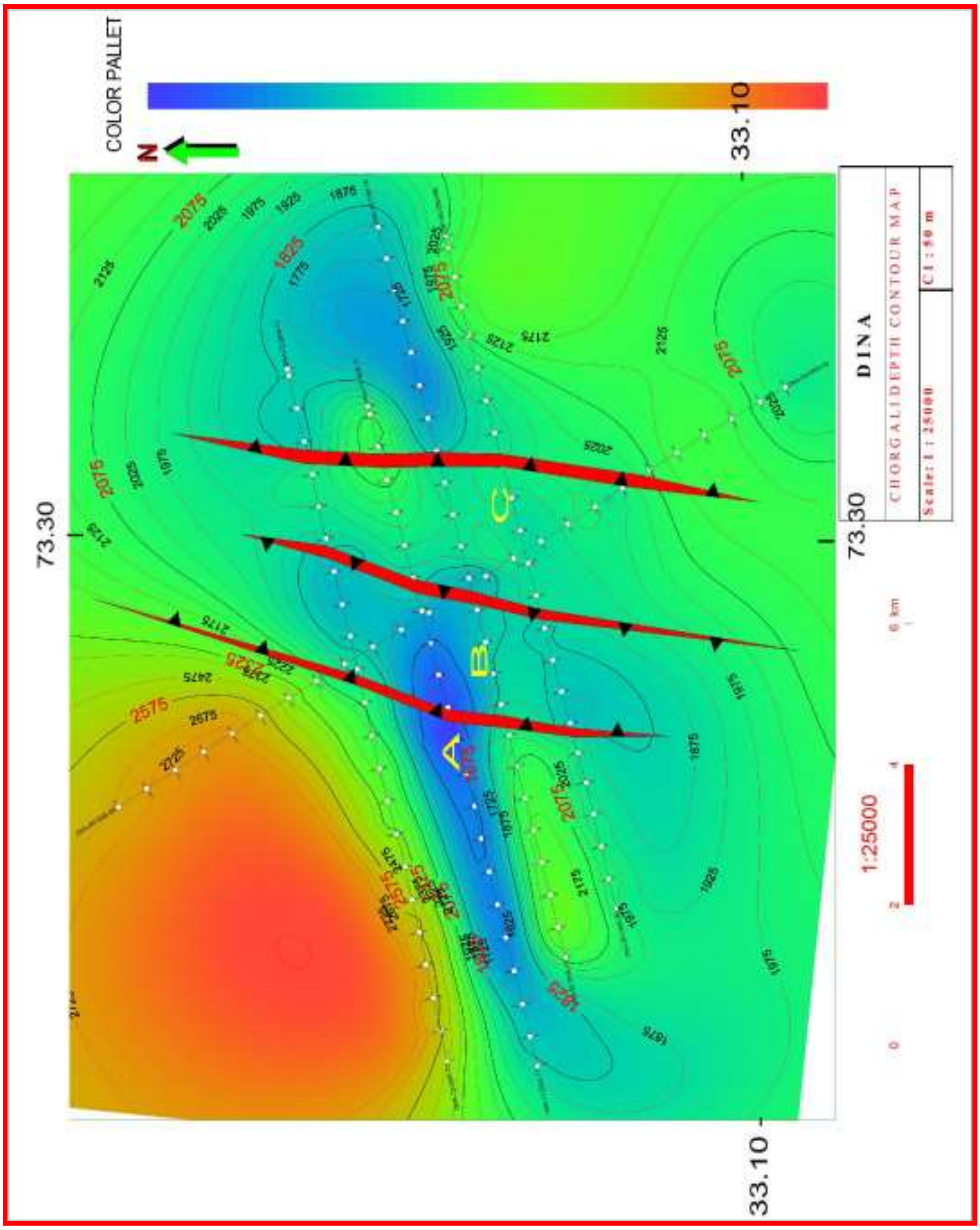

Figure 4.13. Depth contour map of Chorgali Formation (R1).

Depth contour map of R1 (Chorgali Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-1 in depth contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.13). Highest value of depth contour is 2725 m and shallowest value of depth contour is 1525 m.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.13). In this zone pop-up structure is present with is fault bounded. Highest value of depth contour is 2025 m and shallowest value of depth contour is 1850 m.

Zone-C

The zone with is in between F1 and F2 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.13). Highest value of depth contour is 2100 m and shallowest value of depth contour is 1975 m.

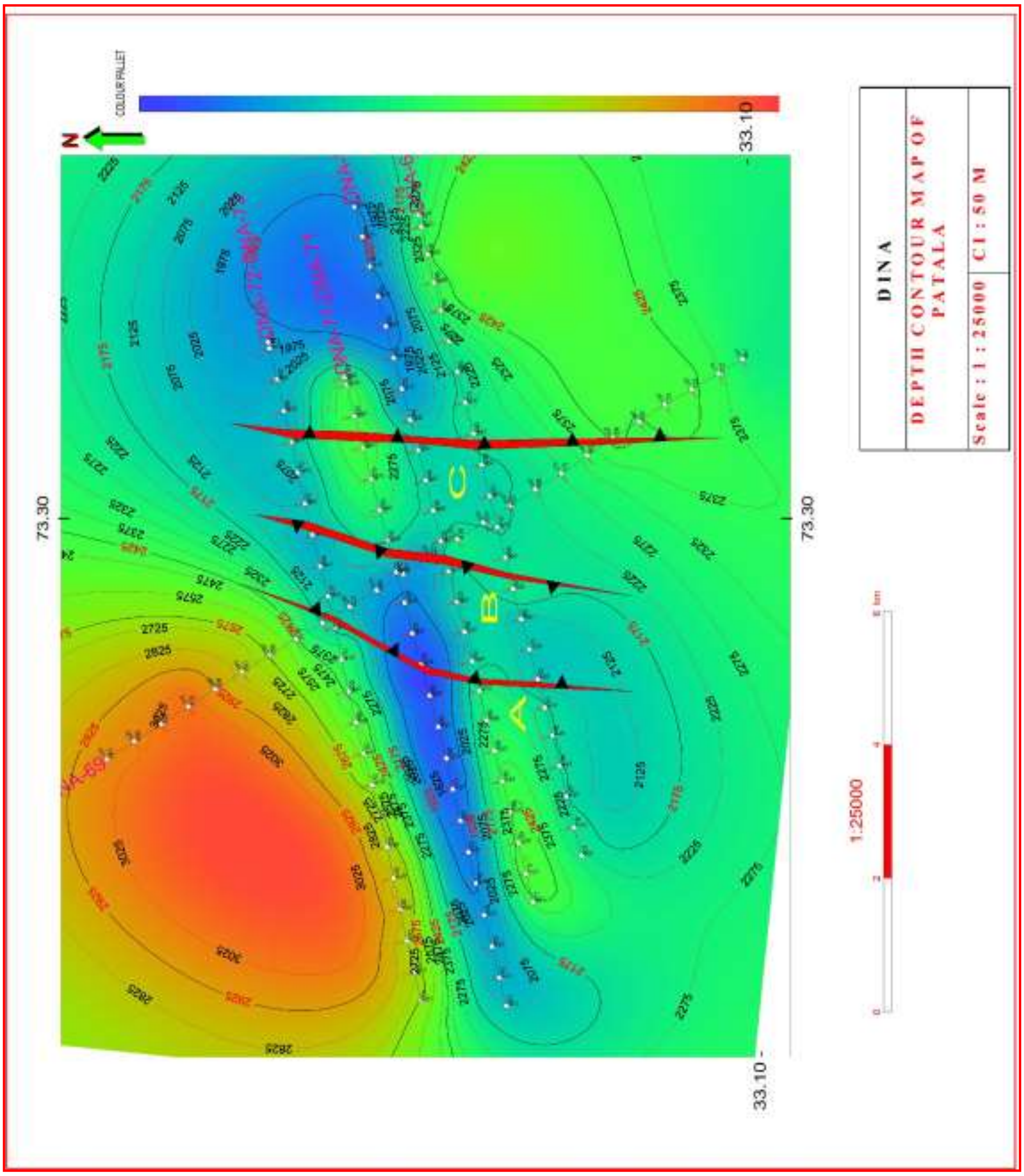

Figure 4.14. Depth contour map of Patala Formation (R2).

Depth contour map of R2 (Patala Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-2 in depth contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.14). Highest value of depth contour is 3025 m and shallowest value of depth contour is 1925 m.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.14). In this zone pop-up structure is present with is fault bounded. Highest value of depth contour is 2325 m and shallowest value of depth contour is 1925 m.

Zone-C

The zone with is in between F2 and F3 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.14). Highest value of depth contour is 2375 m and shallowest value of depth contour is 2075 m.

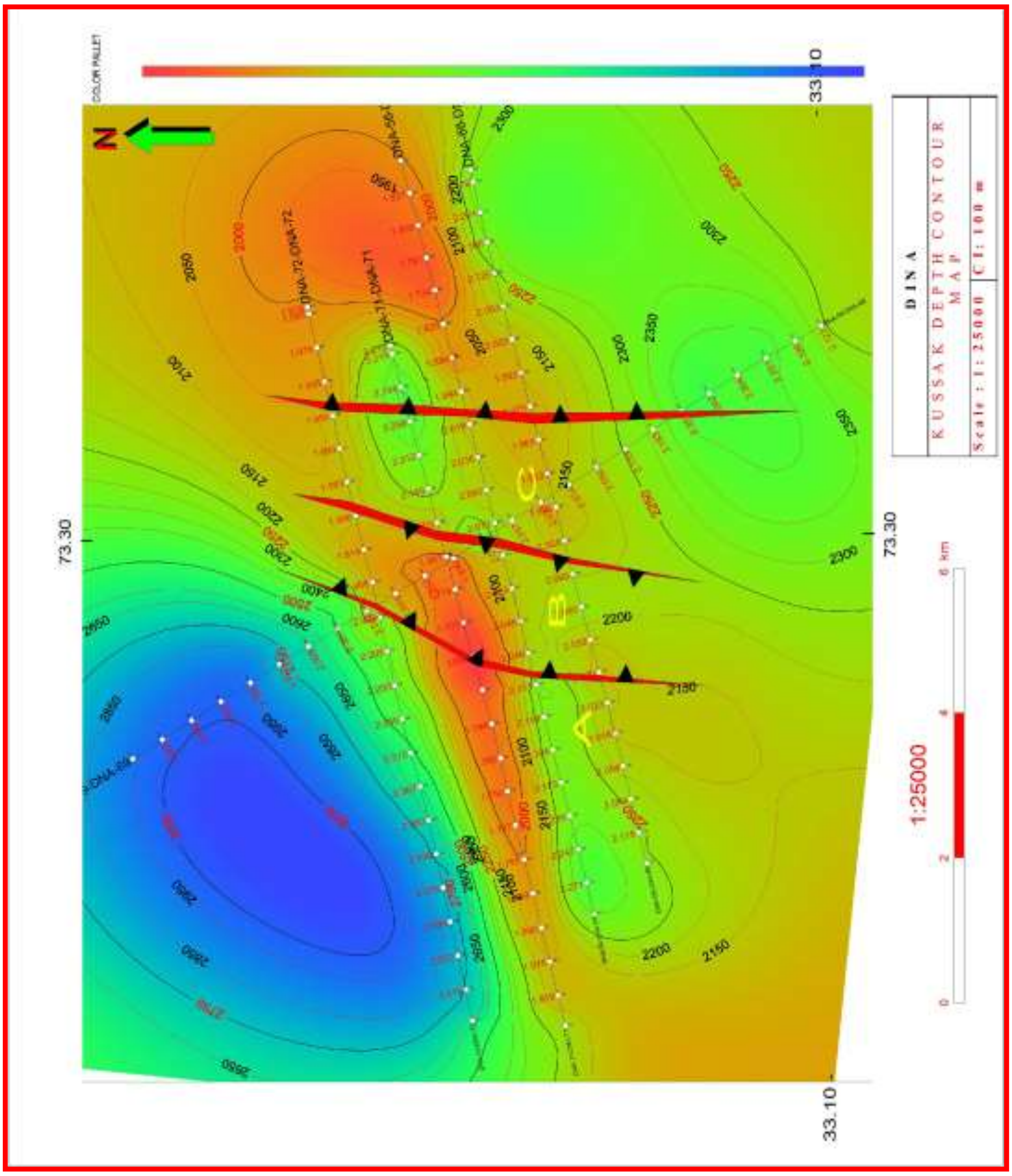

Figure 4.15. Depth contour map of Kussak Formation (R1).

Depth contour map of R2 (Kussak Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-3 in depth contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.15). Highest value of depth contour is 3050 m and shallowest value of depth contour is 2000 m.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.15). In this zone pop-up structure is present with is fault bounded. Highest value of depth contour is 2350 m and shallowest value of depth contour is 1950 m.

Zone-C

The zone with is in between F2 and F3 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.15). Highest value of depth contour is 2400 m and shallowest value of depth contour is 2100 m.

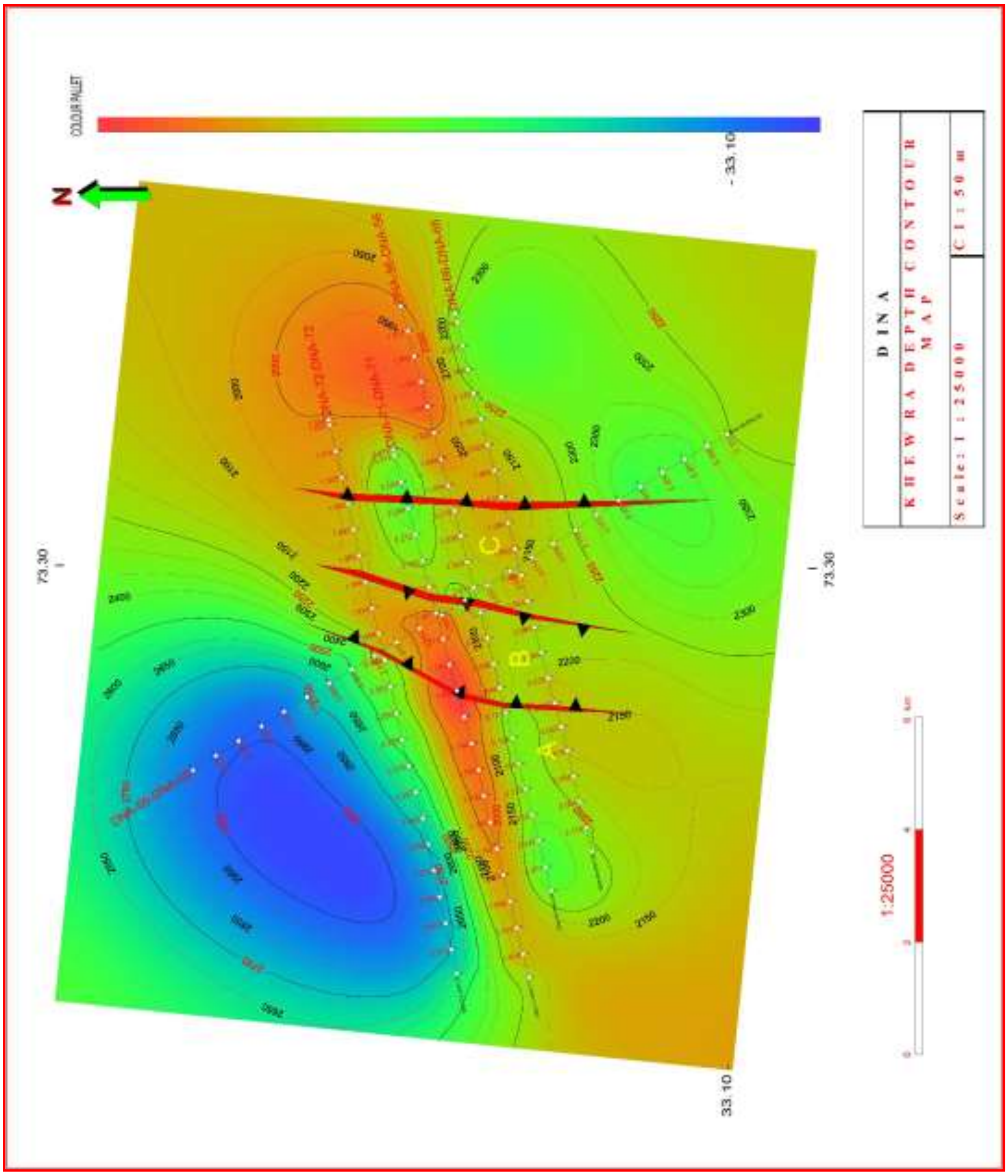

Figure 4.16. Depth contour map of Khewra Formation (R4).

Depth contour map of R4 (Khewra Formation)

Map shows compressional tectonic environment with faulted anticlines and pop-up structural traps along with thrust faults is exhibited. Major and minor thrust faults are in NW-SE direction. These thrust are running almost parallel to each other. To understand the structure the R-4 in depth contour map is divided into three zones.

Zone-A

In this zone in which comprehensive structure lies in the NW side of project area in which one fault bounded closures is present (Fig. 4.16). Highest value of depth contour is 2850 m and shallowest value of depth contour is 2100 m.

Zone-B

It is the major interested zone that lies in the center of the project area (Fig. 4.16). In this zone pop-up structure is present with is fault bounded. Highest value of depth contour is 2300 m and shallowest value of depth contour is 1925 m.

Zone-C

The zone with is in between F1 and F2 is acting as the foot wall for both faults. This zone is in the east side of the project area in with one fault bounded closure is present (Fig. 4.16). Highest value of depth contour is 2400 m and shallowest value of depth contour is 2125 m.

4.8 Explanation

These depth contour maps exhibited some important features,

(a) Fault propagation mechanism and

(b) Throw of the faults

(a) Fault propagation mechanism

On seismic sections three major thrust faults had been identified that were named as F1, F2and F3. All of three thrust faults were passing the all four probable reflectors. These thrust faults are the cause of developing thrust and pop-up structure. Pop-up structure shows the highest portion of the area. The structure exists between the F2 and F3 which is the deepest portion of the project area.

(b) Throw of the fault

The throw of the faults diminished from top to bottom. Throw of the fault on reflector one was maximum (20msec), whereas the throw of the faults were 10-20msec on reflector two and three, and the throw of the fault on reflector four was minimum (6-8msec).

4.9 Geoseismic earth model

Geo seismic earth model is generated with the help of interpreted seismic lines to understand the stratigraphic setting of the area on the time section. Green color indicates Eocene section, blue-Paleocene, orange-Permian, and gray color indicates Pre Cambrian section. F1 (yellow), F2 (purple), F3 (black).

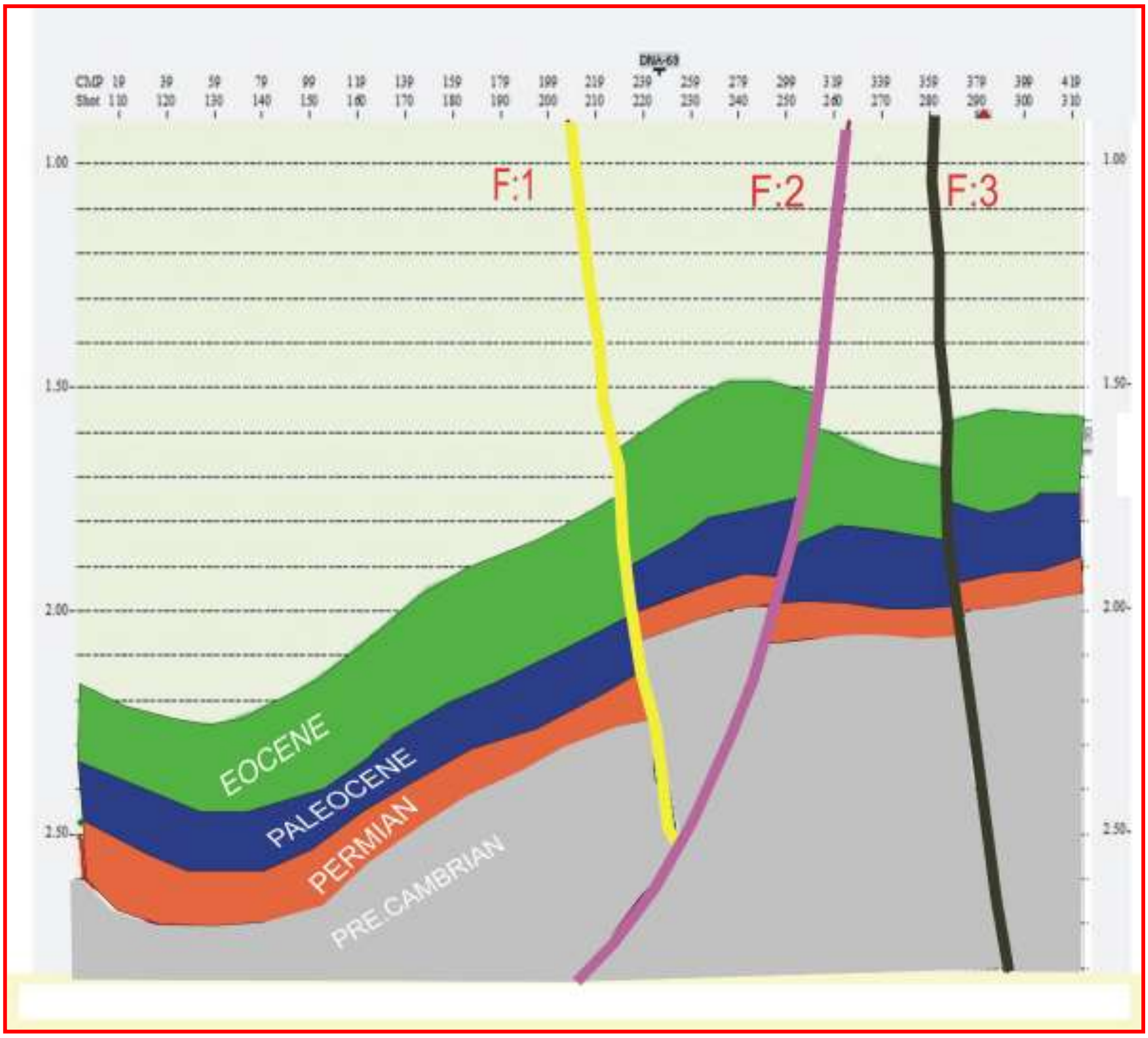

Figure 4.17. Geoseismic earth model developed on line # 942-DNA-72.

CHAPTER 5

SEISMIC ATTRIBUTES ANALYSIS

5.1 Introduction

Seismic attributes are defined as the information collected from seismic data in carrying out attribute analysis, information gained from seismic data is utilized either by direct measurements or by logical or experience based reasoning (Taner, 2001). The study and interpretation of seismic attributes give some qualitative information of the physical parameters and the subsurface geometry.

The amplitude part of the seismic data determines the physical parameters, such as the velocities, reflection coefficients and acoustic impedance. The phase content determines the shapes of the reflectors and their geometrical configurations.

5.2 Total phase

Total phase describe the phase angle of a signal at any degrees (-180 to +180). The phase response is quite helpful in picking horizons continuity especially sequence bounding surfaces. It is an analytical way to amplitude tuning effects. In other words, when amplitude attributes are biased by the constructive and then destructive interference of reflectors as they come closer together, instantaneous phase can confirm that the amplitude changes are due to tuning and not due to hydrocarbons or other effects. Because wave fronts are described as lines of constant phase, the phase attribute can be effectively used for geometrical shape classifications (Taner, 2001).

The value range of total phase amplitude is this survey +16 to -16 and the value of Chorgali Formation at Shahab 1 well location ranging from 2 to 6 (Fig 5.1).

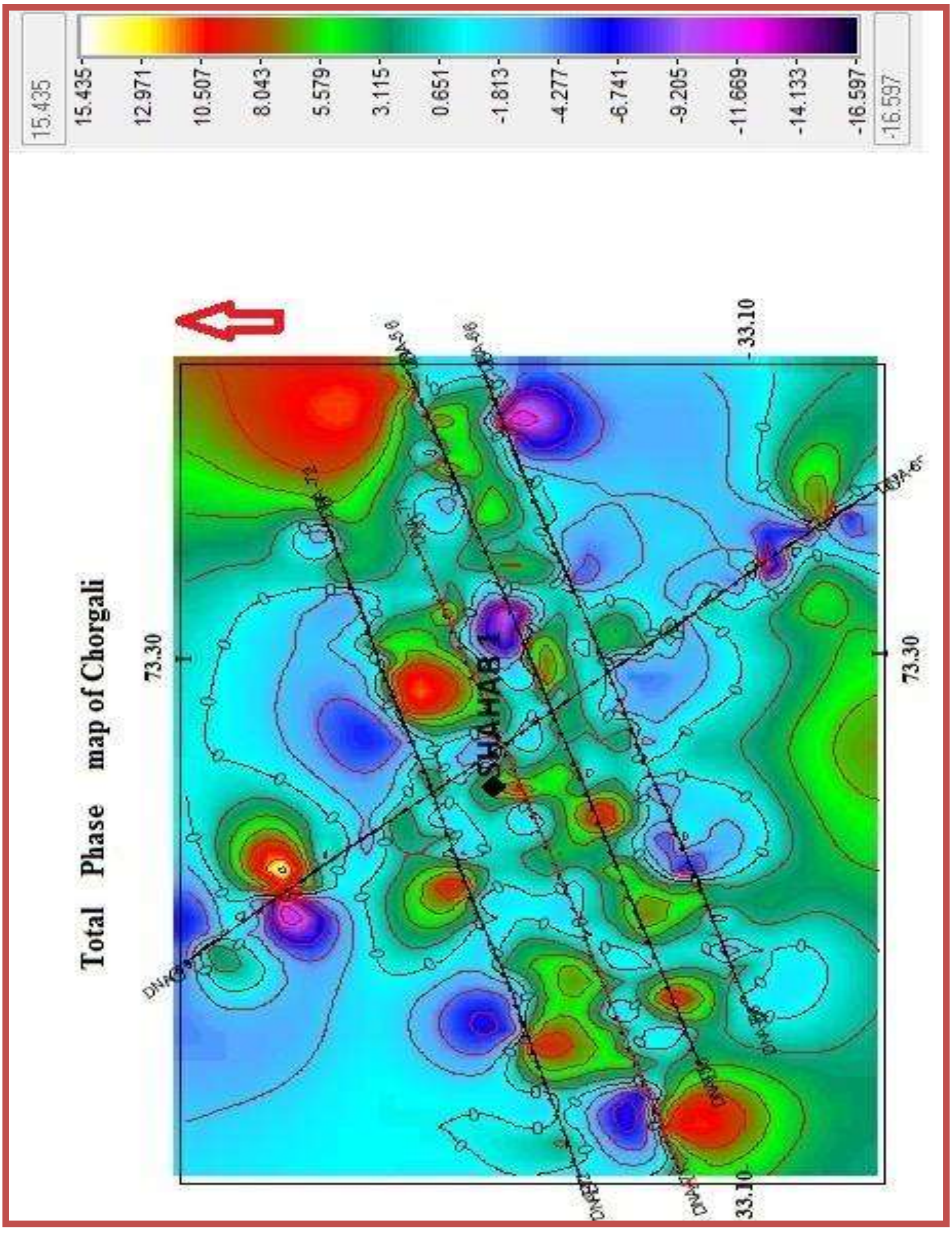

Figure 5.1. Total phase map of Chorgali Formation.

5.3 Average instantaneous frequency

It is defined as the first derivative of the instantaneous phase. It describes on a display section how quickly the phase of the complex traces changes. A frequency map is quite useful in finding pinch-outs or edges of hydrocarbons and water traps. Average Instantaneous Frequency represents the rate of change of instantaneous phase as a function of time.

dp (t) / d (t)………………………………………………………Eq(5.1)

As;

p (t) = Instantaneous phase trace

The seismic window for this statistic should cover one or a few reflectors (30-100 ms), expect to find an average diagnostic frequency. The computation of instantaneous Frequency is the time derivative of phase, and its meaning have been the subject of a number of papers. (Cohen, 1995, Barnes, 1991; Barnes, 1992). The instantaneous frequency attribute responds to both wave propagation effects and depositional characteristics, hence it is a physical attribute and can be used as an effective discriminator.

Chorgali Formation ranging from 17 to 21 at Shahab 1 well location (Fig 5.2). As we know frequency is directly related to the velocity and also velocity gets low when the fluids presence in the subsurface. For ideal reservoir zone frequency should be low but this average instantaneous frequency value is not quite lower at Shahab 1 well than the surrounding area suggesting the fact of dry well and no hydrocarbon presence. These values may indicate the presence of Limestone which is a good reservoir.

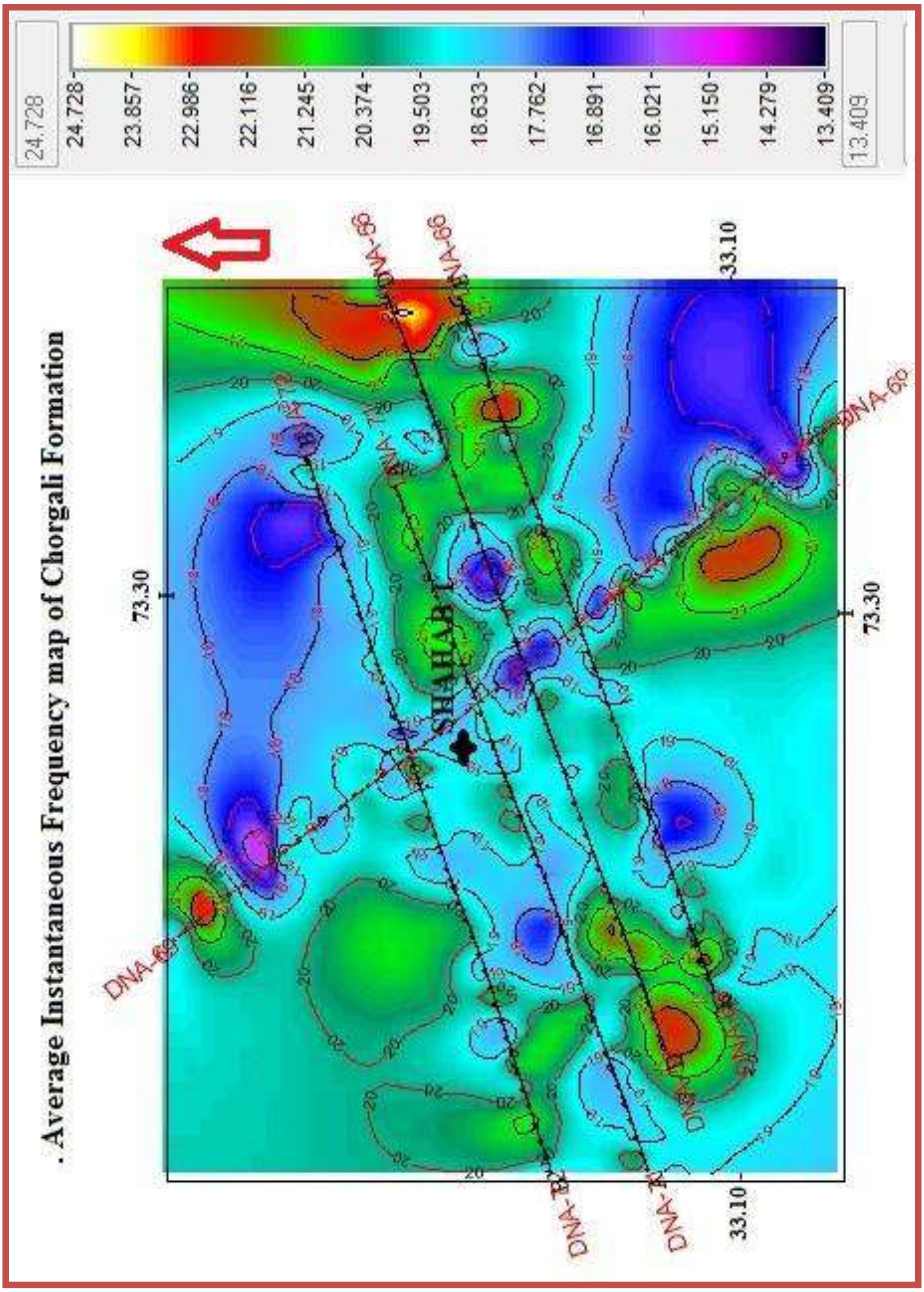

Figure 5.2. Average instantaneous frequency map of Chorgali Formation.

5.4 Total amplitude

Reflection strength or Instantaneous amplitude is the square root of the total energy of the seismic signal at an instant of time. is calculated as follows:

$$\text{Reflection}=\sqrt{(\text{recorded trace})^2+(\text{quadrature})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{Eq}(5.2)$$

Total amplitude value is calculated by adding all amplitudes within the selected window. The window is defined as, 10 msec in length and 10 msec offset from reflector Chorgali (R1).

Calculated values fall in range of 250 to 1000 at Shahab-1 location (Fig. 5.3). The high value indicates less chance for the occurrence of hydrocarbon. The Total amplitude map for R1 indicates from north to south amplitude value changes. However the change in amplitude values is more as in the north portion. On seismic line DNA-942-71 at the Shahab 1 well location the values are very high which may be the cause of failure of well.

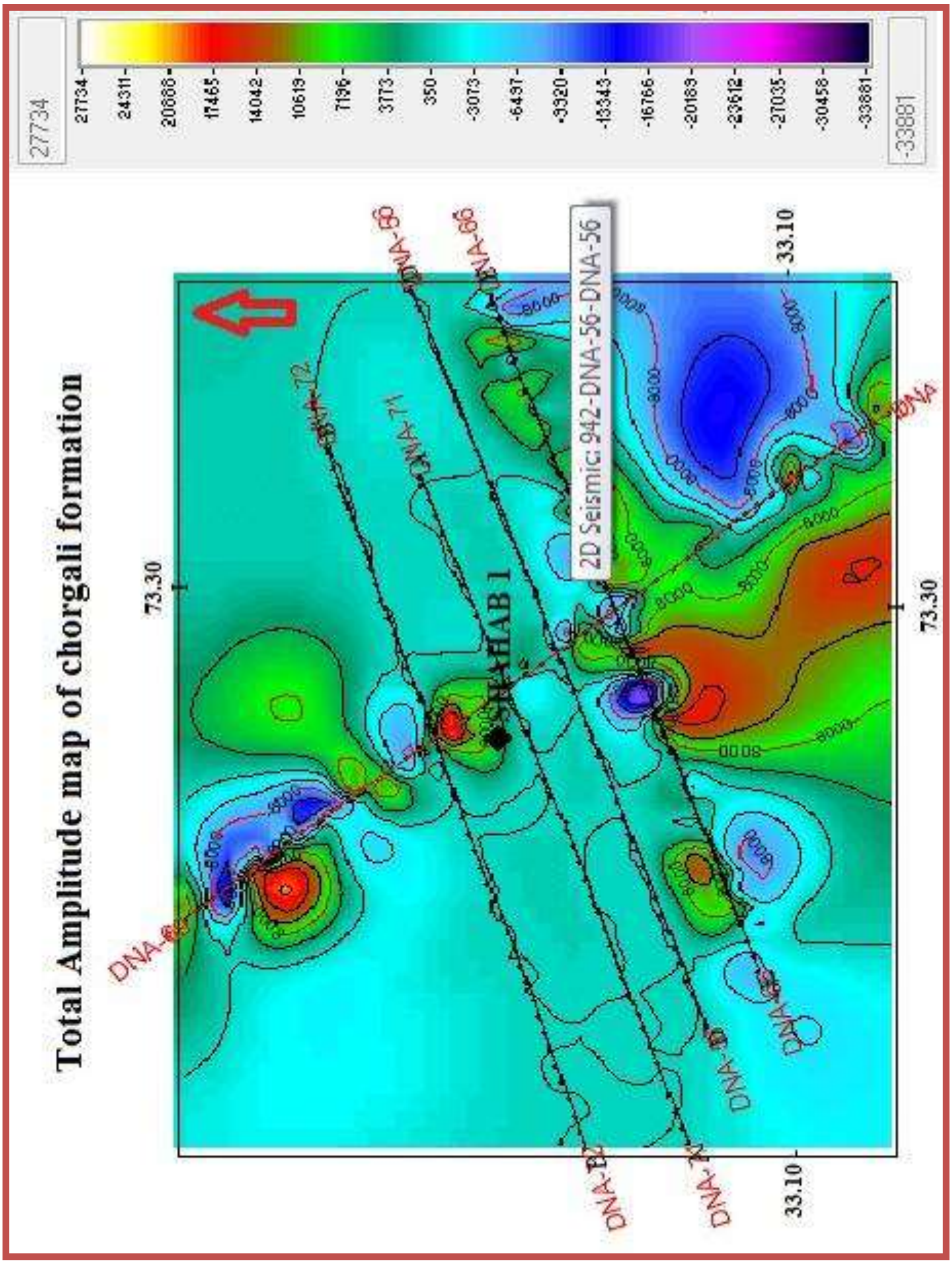

Figure 5.3. Total amplitude map of Chorgali Formation.

5.5 Results of seismic attributes

The values of seismic attributes at Chorgali Formation indicates the absence of hydrocarbon (Fig 5.2 and Fig 5.3) but confirms the present of lime stone. Values of these attributes are very high for presence of oil and gas. Since Shahab 1 well is dry well and abandoned at Eocene section, it confirms the results of seismic attributes.

DISCUSSION AND CONCLUSIONS

(1) Project area, Dina lies in the Eastern Potwar Basin. The seismic study of the project area is in agreement of previous publish data and reconfirms the point that area had undergone thrusting resulting in the generation of thrust faults with triangle zone and pop-up structures. Among these structures, pop-up structures are the most suitable for petroleum entrapment. There are some fault bounded closures which can be the probable hydrocarbon traps.

(2) It can be concluded based upon the available data that reflector one (yellow) is probably Chorgali Formation. Similarly, reflector two (orange) represent probably the Patala shales, reflector three (green) represent probably the Kussak and the reflector four (read) is probably the Khewra" Sandstone.

(3) Three main thrust faults (F1, F2, and F3) are identified. In this region there might be some other minor faults that can be interpreted in 3D data but due to poor 2D data quality it's difficult to interpret.

(4) Throw of faults decreases from top to bottom. Two major faults F1 and F2 having 10 to 20 ms of throw at R1 and R2, then 10 ms at R3 and at R4 it decreases to 6 to 10 ms.

(5) In depth contour map of probable Chorgali Formation, zone-B is the major interested zone where a prominent fault bounded closure is present which is two ways fault bounded in east-west and two ways dip bounded in North-South.

(6) The interpretation also shows the fault propagation mechanism. Throw of the faults and thicknesses of the reflectors can also be very helpful in order to drill the further. The dip of the thrust faults in NW-SE and NE-SW direction.

(7) The seismic attribute analysis also helps to identify the reservoir zone top and values of amplitude and phase helped to reason the dry Shahab 1 well.

(8) Area of the Shahab structure is very small. Shahab 1 well was drilled on the prominent popup structure.

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