2D Seismic Interpretation and Study of Rock Physics of Tajjal Area, Lower Indus Basin, Pakistan

QUAID-I-AZAM UNIVERSITY

ISLAMABAD

BY

Syed Aun ur Rab

BS (GEOPHYSICIS)

DEPARTMENT OF EARTH SCIENCES

QUAID-I-AZAM UNIVERSITY, ISLAMABAD,PAKISTAN

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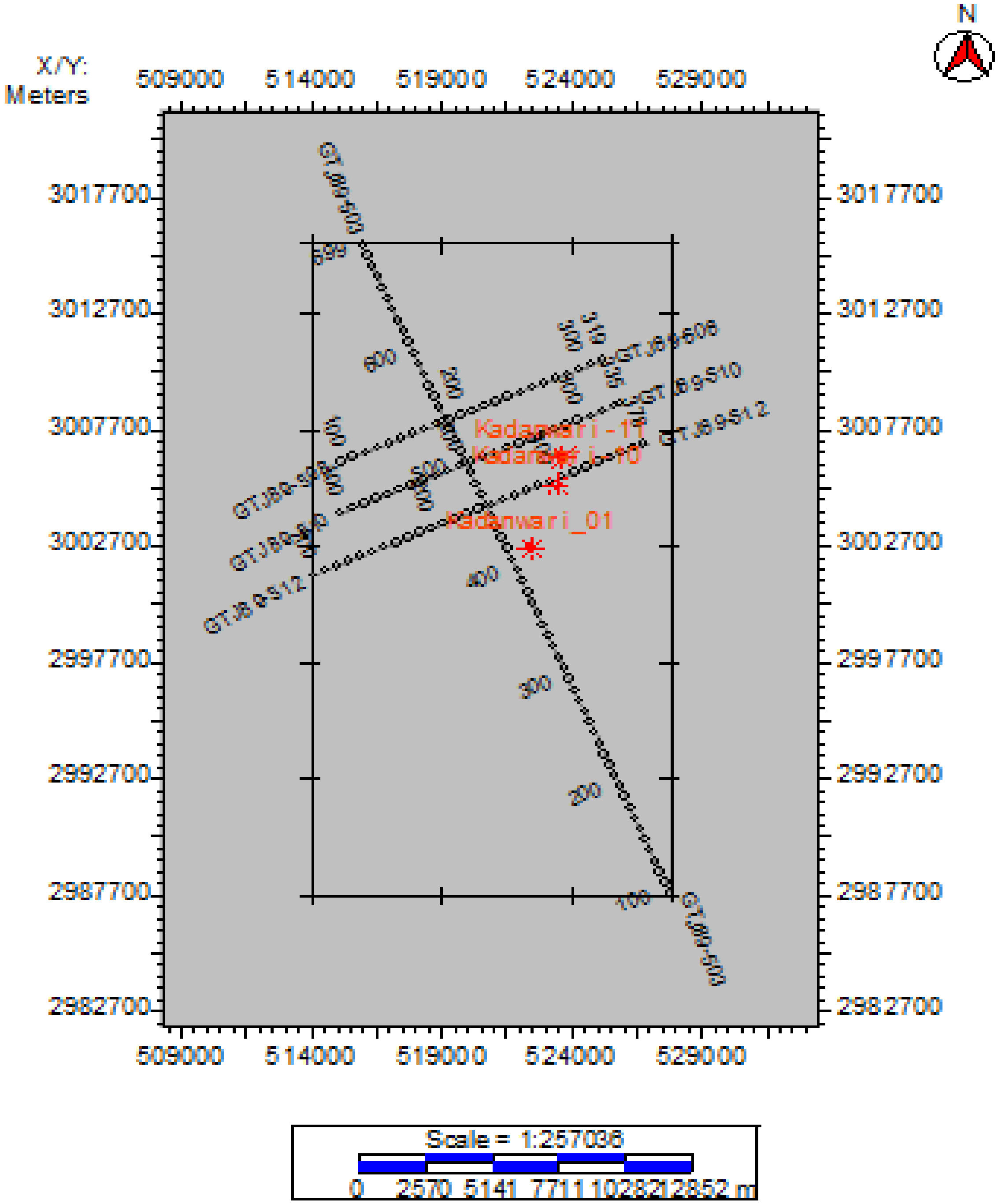
CHAPTER 1

1.1 INTRODUCTION OF THE AREA

The area lies near the boundary of Lower and Middle Indus Basins. All in all it lies in the Lower Indus Basin. The area is important for its gas fields mainly SAWAN, MIANO, KADANWARI, PIRKOH, SUI etc. The area assigned lies in the Sawan field. The fields are in stratigraphic traps. Mainly the data of SAWAN 3B well has been used. The area is included in the 1015210N to 1041208N and 2816478E to 2853525E. Figure 1.1 is the basemap of the area.

1.2 BASE MAP

A construct outline the guide in light of which information can be plotted. The base map is vital for elucidation perspective since it delineates the spatial area of seismic section and furthermore indicates how seismic section are interconnected. A base map ordinarily incorporates area of rent and concession limits, wells, and seismic study focuses. Base map gives the structure to contouring. The base map of the range is created by stacking information in Universal Transverse Mercator (UTM, zone 42N) geodetic reference framework in SMT Kingdom 8.6. The base map, given in Figure 1.1 which demonstrates the introduction of the lines show in the Tajjal region. Four lines used to construct the base map are give in Table 1.1



: **Figure.1.1**: Base map of study area.(UTM zone: 42N).

FIGURE.1.1 BASE MAP OF TAJJAL AREA WHICH SHOWS ORIENTATION OF SIESMIC LINES WHICH ARE ALONG GIVEN LINE GTJ89-503-GTJ89-512

1.3INTRODUCTION TO SEISMIC LINE

Seismic survey was carried out in Tajjal area in March 1988. The party number is 213-34-18. The data acquisition and processing were made on selecting appropriate field parameters. This dissertation pertains to the interpretation of CDP Nominal 60 fold data. The Line number is TJ503,508,510,512 Although one line is not sufficient to map the structure, but I made an attempt to make base map by combination of adjacent three lines which are GTJ89-508, GTJ89-510, GTJ89-512, and ONE STIRKE LINE IS 503.

Sr.no.	Line name	Dip/Strike	Orientation
1	GTJ89-503	Strike	NW-SE
2	GTJ89-508	Dip	NE-SW
3	GTJ89-510	Dip	NE-SW
4	GTJ89-512	Dip	NE-SW

Table1.1: Seismic lines description

1.4 SURVEY PARAMETER

Quality of field data depends upon the setting of survey parameter. If the field parameters are selected appropriately then we get the good quality of data. Survey parameters consist of :

1) Shooting Parameter
2) Recording Parameter
3) These parameters depend upon four variables

4) Source Size
5) Source Depth
6) Number of Holes
7) Group Base

- Notch Filter: OUT

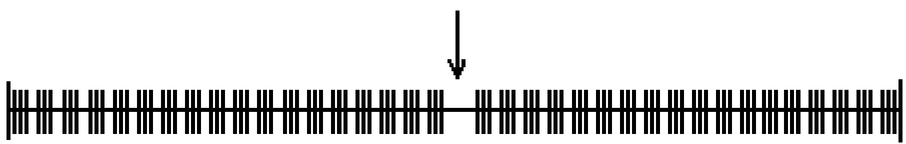
- Record Length: 6 S
- Sample Rate: 4MS.
- CDP Nominal Fold: 60

1.4.1 RECORDING PARAMETERS

Geophone per Group:	**36**
Number of Groups:	**120**
Geophone Interval:	**1.39 M**
Group Interval:	**50 M**

1.4.2 SPREAD DIAGRAM

TR 1 **120**



3025 M **3025 M**

*** SOURCE ARRAY*** *** GEOPHONE ARRAY***

113.3 M

- o o o o] -------25M------ [

* X X X

-o o o o

] ---------------- 80 m ---------------- [ ] ------------------- 48.6---------------- [

1.4.3PROCESSING SEQUENCE OF SEISMIC LINE

This line was processed by OMV in March. The processing sequence of the seismic line is given in the following table.

1. REFORMATING TO CGG FORMAT
2. GEOMATRY LABEL
3. BAD TRACE EDIT
4. SPHERICAL DIVERGENCE CORRECTION
5. F-K FILTRING ON V.P AND GEOPHONE DOMAIN TO DE-ATTENUATION
6. COMMON DEPTH POINT GATHER
7. DYNAMIC EQUILIZATION* - SINGLE GATE 6000 MS
8. FIRST BREAK MUTE
9. MONO-CHANNEL GAPPED DECONVOLUTION GAP=24MS

DIGNE GATE	OP. LENGTH	REWHITENING
– 0.8	120 MS	5 PERCENT

10. COMMON DEPTH POINT GATHER
11. FIELD STATIC CORRECTION TO FLOATING DATUM PLANE
12. VELOCITY ANALYSIS* - VELOCITY SPECRTRA EVERY 2KM
13. NORMAL MOVEOUT CORRECTION (NMO)
14. MUTING* -
15. AUTOMATIC SURFACE CONSISTENT M.O RESIDUAL STATICS*
16. AUTOMATIC SURFACE CONSISTENT S.W RESIDUAL STATICS*
17. DYNAMIC EQUILIZATION* - OPERATOR LENGTH 1000 MS
18. DIP MOVE OUT* (PARTIAL STACK WITH RESIDUAL NMO)
    (SINE OF DIP ANGLE KF = 0.5)
19. VELOCITY ANALYSIS* -VELOCITY SPECTRA EVERY 1 KM
20. DYNAMIC EQUILIZATION* - OPERATOR LENGTH 1000 MS
21. STACK* - NOMINALLY 60 FOLD

22. FX DOMAIN RANDOM NOISE ATTENUATION
23. STATIC CORRECTION TO DATUM SEA LEVEL
24. F.D. DIP CONTROL MIGRATION

1.5AIMS OF THE STUDY

Following are the points and goals of this investigation:

- To comprehend subsurface geology of study region.
- To translate the subsurface structure.
- To check the horizons and faults.
- Seismic attribute investigation to confirm the interpretation.
- To examine the physical behavior reservoir zone by utilizing Rock physics parameters.

CHAPTER # 2

GEOLOGY OF THE AREA

2.1 INTRODUCTION

The most noticeable reality with respect to physical topography and geography of the Indian locale is that it involves three unmistakable units which are not quite the same as each other in their physical and in addition geographical attributes. The two among these three units has crucial premise in India and unmistakable characters of these were urged it from early time of its land history and from that point forward every region has sought after its own singularity. These three divisions are;

1. The triangular Plateau of the Peninsula (i.e. the Deccan, south of the Vindhyas), with the island of Ceylon.

2.The sloping district of Himalayas which guests India with west, north and east, including the nations of Afghanistan, Baluchistan and slope hints of Burma, known as the additional promontory.

3.The extraordinary Indo-Gigantic plain of Punjab and Bengal isolating the two previous regions and stretching out from the valley of the Indus in Sindh to that of the Brahmaputra in Assam. (Wadia,1952).

2.1.1 Physical Characters of the Plains of India:

The third division of India, the great alluvial plains of the Indus and Ganges through, humanly speaking of the greatest interest and importance as being the principal theatre of Indian history ,is ,geological speaking , the least interesting part of India. In the geological history of India they are only the annuls of yester-year, being the alluvial deposits of rivers of the Indo-Ganges systems, borne down from the Himalayas and deposited at the their foot. They have covered up, underneath a deep mantle of river-clays and silts, valuable records of past ages, which might have thrown much light on the physical history of Peninsular and Himalayan areas and revealed their former connection with each other. These plains were originally a deep depression; there is some difference of opinion. Burrard from some anomalies in the observations of the deflections of the plumb-line and other geodetic considerations has suggested quite a different view. He thinks that the Indo-Gangetic alluvium conceals a great deep rift, or fracture, in the earth's sub crust, several thousand feet deep, the hollow being subsequently filled up by detrital deposits. He ascribes to such sub-crustal cracks or rifts a fundamental importance in geotectonic and attributes the elevation of the Himalayan chain to an incidental bending or curling movement of the northern wall of the fissure. Such sunken tracts between parallel, vertical dislocations are called "Rift – Valleys" in geology. **(Wadia, 1952)**

2.1.2 Structure of the Area (Ahmed et al, 2004):

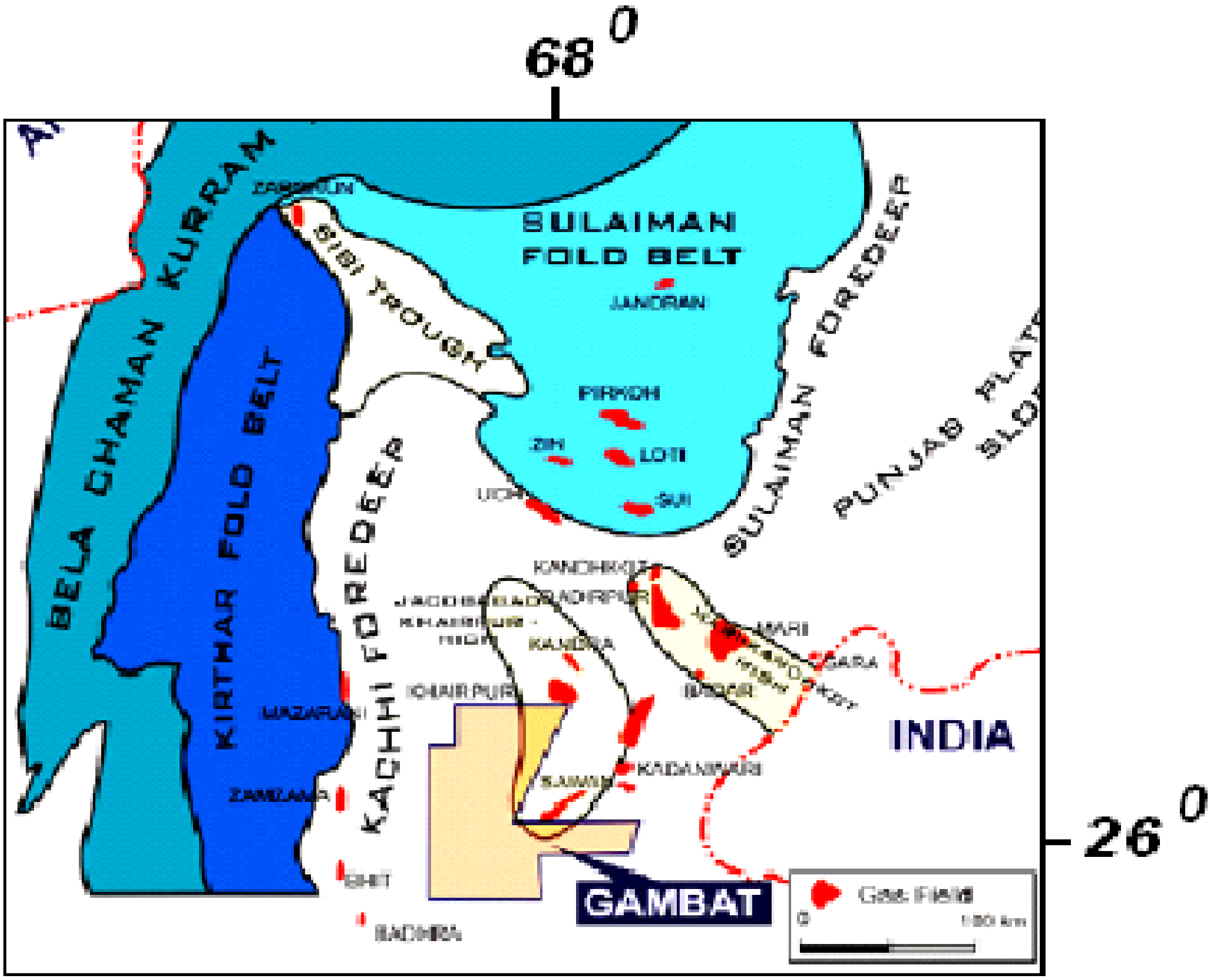


Fig 2.1: Location and structure map of the studied area after Ahmed et al, 2004

Fig 2.1 shows that in the North of the studied there is Sulaiman Fold belt and in the South there is Kirher Fold belt, towards east is Indian Shield and towards West is Kirther Fold Belt. The Studied area lies in Lower Indus Basin in Pannu-Aqil Graben which part of Sukkar Rift Zone which comprises of Mari Khandkot High, Jacobabad-Khairpur High and Pannu-Aqil Graben. This Sukkar Rift Zone divides the Central Indus Basin and Lower Indus Basin. The area has been traversed by Normal Faults forming Horst & Graben Structures. This means that area has been operated by extensional forces and is more prominent near the boundary between Jacobabad-Khairpur High and Panno-Aqil Graben. (Ahmed et al, 2004)

2.2 TECTONIC FRAMEWORK OF PAKISTAN

Pakistan is one of a kind in as much it has a place with the two areas of landmasses, i.e. Tethyan Domain and Gondawanian Domain and is supported by the Indo-Pakistan crustal plate. The northern most and western areas of Pakistan fall in Tethyan Domain that present an entangled topography and complex crustal structure. **(Kazmi and Jan, 1997).** Pakistan incorporates nearly the three divisions of Landmasses. On the premise of plate structural elements, geologic structure, Orogenic history (age and nature of twisting, magmatism and transformative nature) and lithofacies, Pakistan might be partitioned into following expansive structural zones; **(Kazmi and Jan, 1997).**

- Indus stage and foredeep.
- East Baluchistan overlay and-push belt.
- Northwest Himalayan overlap and-push belt.
- Kohistan-Ladakh magmatic circular segment.
- Kakar Khorasan flysch bowl and Makran accretionary zone.
- Chaghi magmatic circular segment.
- Pakistan seaward.

2.2.1:Indus Platform and Foredeep :

This zone stretches out finished a territory surpassing 2,50,000 Km2 in southeastern Pakistan and incorporates the Indus plain and Thar-Cholistan deserts. It has over 80% of Pakistan's populace, broad coal stores, variable oil and gas fields potential for geothermal vitality and immense groundwater reservoirs.**(Kazmi &Jan, 1997).**

Gravity and seismic reviews, upheld by restricted borehole information show that the eastern part Precambrian rocks from delicate westbound plunging monocline secured by finishes of Mesozoic to Cenozoic marine to deltaic silt. Be that as it may, there are wide zones of up wrap and down wrap which are all around characterized by gravity overviews. The sedimentary heap, especially the fore profound at the western edge of stage incline where the sedimentary cover is up to 10,000 m thick. **(Kazmi and Jan, 1997)**.

2.2.2:Structural Zones:

The Indus platform and foredeep comprise the following main structural zones.

- Buried Rides:
  - Sargodha-Shahpur ridge.
  - Nangaparkar ridge.
- Zones of up-wrap:
  - Mari-Khan dot high.
  - Jacobabad-Khairpur High
  - Tharparker High.
- Zones of downwrap and slope:
  - Northern Punjab monocline.
  - Southern Punjab monocline.
  - Cholistan Shelf.
  - Panno Aqil Graben.
  - Nawabshah slope.
  - Lower Indus Trough.
  - Nabisar slope.
- Fore deeps:

Suleiman fore deep.

Kirther fore deep.

This image cannot currently be displayed.

Fig 2.2: Tectonic Zone Of Pakistan (www.gsp.com.pk)

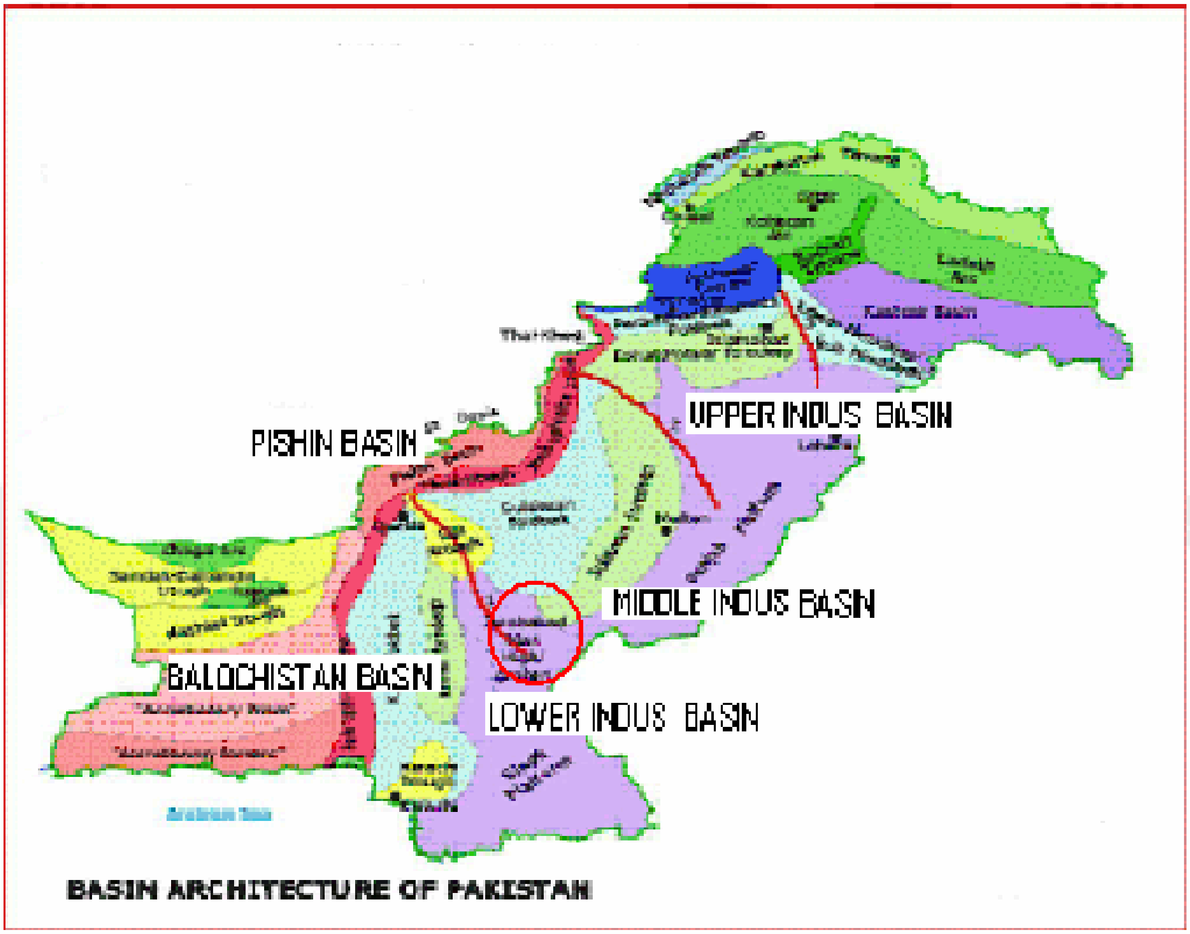
2.3:THE INDUS PLAIN'S CHARACTERISTICS:

As expressed in segment 2.1 that the promontory as an earth highlight holds particular component from the additional landmass. of the considerable number of contrasts:

The primary contrast is stratigraphy, or that associated with the geological history of range. From the Cambrian time frame the Peninsula has been a land region, a mainland piece of earth's surface which since that age in the world's history has never been submerged in underneath the ocean, aside from briefly and locally. No extensive Marine residue of later age than Cambrian was even kept in the inside of land mass. the additional Peninsula then again, has been a locale which has lain under the ocean for the larger part o its history.

The second distinction is geo-structural. The Peninsula of India uncovers a significant distinctive kind of engineering of earth's outside layer from that appeared by the additional Peninsula. Peninsular India is part f earth's external shell that involves the most established shake beds that remain upon the firm and The ardent establishment. Horizontal pushes and mountain building powers have had little impact in collapsing or dislodging its unique cellar. The strata wherever indicates high plunge points, firmly stuffed folds and other savage takeoffs from unique structure.

The third contrast is the differing qualities in physiography of the two zones. The distinction lies in outer or surface help. In the Peninsula, the mountains are for the most part of RELICT nature i.e. they are not mountains in the genuine feeling of the term, however are minor remarkable segments of old level of the promontory that have gotten away, for some reason, the weathering of ages that has removed all the encompassing parts of the land ; they are so to state are enormous valleys, with low indistinct inclinations, on account of their channels having drawn nearer to the base level of the disintegration. Appeared differently in relation to alternate piles of additional landmass are genuine mountains or TECTONIC mountains i.e. the individuals who owe their root to a particular elevate in the world's outside layer and accordingly have their spike or line of expansion, pretty much confirmable to the pivot of that inspire. The waterways of this region are quick torrentional streams, their dissolving power are constantly dynamic and they have sliced profound crevasses through the mountains in the rugged piece of their track.



1. **Fig 2.2 Basins of Pakistan (www.gsp.com.pk)**

2.4 LOWER INDUS BASIN:

This bowl in portrayed by latent rooftop duplex sort structure and a uninvolved back pushed along the Kirther Fold belt, a Passive rooftop push shaping a front summit divider along the edge of crease belt well along the edges of overlap belt and the Kirther despondency and out of syncline intra molasses separations in the Kirther melancholy arrangement. The Kirther and Karachi melancholies contain a few huge anticlines and arches and some of these contain little gas fields. The eastern piece of the bowl containing the Sindh monocline is generally involves blamed and tilted squares of Mesozoic rocks from which basic traps overlain by Deccan trap Basalt and Tertiary sedimentary rocks. The Northern edge of lower Indus Basin involves the Suker Rift Zone which bears extensive anticline structures and contains the Khandot and Mari Gas fields. Figure 2.1 demonstrates the Tectonic guide of lower Indus Basin.

The fundamental supply shakes in the Sindh Monocline are Cretaceous Lower Goru sandstone. In Karachi sorrow creation is from Paleocene Ranikot Limestone and sandstone, in Kirther depression and Sukker Rift zone it is of Eocene Sui Main/Habibrani Limestone. The lower Indus bowl is likewise described by high geothermal slopes which go from 2 to more than 40C/100m Figure 2.2 demonstrates the oil and gas disclosures in Lower Indus Basin. (IQBAL QADRI)

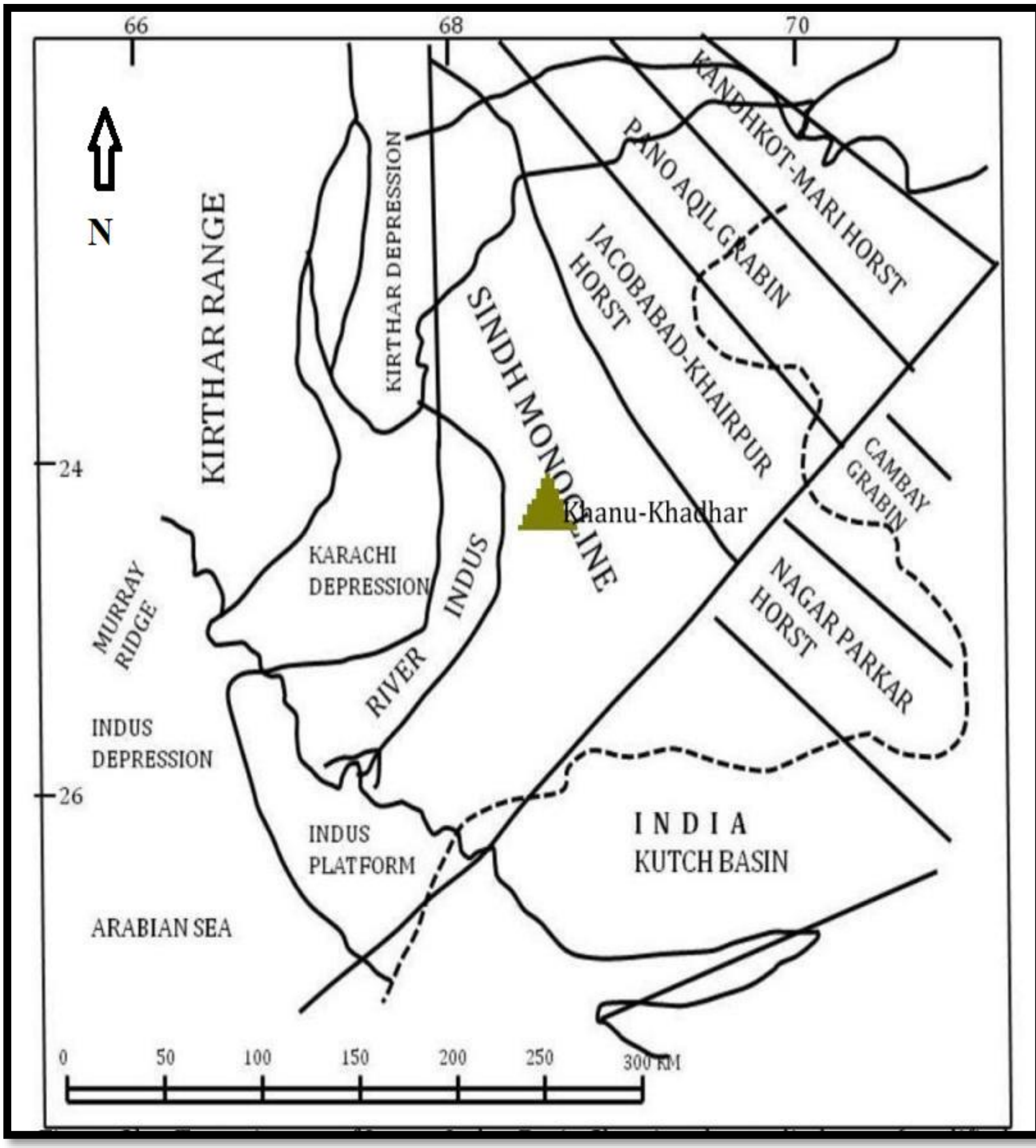


Fig 2.3 Oil and gas discoveries in Lower Indus Basin.

2.5 STRUCTURE OF THE STUDIED AREA

All of the lower Goru revelations are situated close to some basic high (Mari high, Jacobabad-Khairpur high, Badin elevate high) which has suggestions for the movement pathways, timing of the supply charge and hydrocarbon capture in basic and stratigraphic highlights. The vast majority of these basic high are reversal highlights recognized on the territorial seismic lines. The primary inspire scene happens close to the K-T limit and is showed as the base Tertiary unconformity. The Paleocene Ranikot disperse towards and spread out and thicken far from these highs. In addition , the greater part of profound storm cellar related and shallower structural related issues end against this unconformity. For the most part the whole Cretaceous area is changing character from unequivocally straight and single blame at top to en-echelon left parallel portion at lower and upper Goru levels. This structural occasion was the aftereffect of trans tensional tectonics identified with first docking of Eurasian plate and experience clock astute revolution of the Indian plate. The second inspire occasion in the center and lower Indus Basin occurred amid the late Eocene-Oligocene times. The auxiliary high most likely experienced repetitive periods of change in light of progressive periods of push stacking in the west and northwest. The last adjustment of the state of traps and possibly the optional hydrocarbons relocation and store charge occurred amid this period.

2.6 STRATIGRAPHY OF THE AREA

In Lower Indus bowl statement of dregs ranges from Precambrian to Pleistocene. The affidavit was however interfered with a few times. Through and through the stratigraphic segment can be partitioned into four gatherings. Fig.2.3 is demonstrating the division of stratigraphic segment their ages and shake sorts.

The stratigraphic progression changes from east to west. The Precambrian storm cellar is westbound. The critical unconformities happen at the base of the Permian and the Tertiary. In the eastern piece of the bowl, the Tertiary has coordinate contact with the Jurassic grouping. The Indus Lower Indus Platform bowl reflects sedimentation related with breaking.

Stratigraphic segment (Table 2.1) experienced in GORWAR-01. Which specifically gives the data about the stratigraphic segment lies in the investigation range.

r.no	Epoch	Formation.	Depth(Meters)
1.	Pliocene-Pleistocene	Siwalik	7.75
2.	Late Eocene	Darazinda	301

3.	Late Eocene	Pirkoh	414
4.	Eocene	Sirki	474
5.	Eocene	Habib Rahi	538
6.	Early Eocene	Ghazij	674
7.	Early Eocene	Sui Main Limestone	1259
8.	Late Paleocene	Lakra	1345
9.	Late Paleocene	Bara	1454
10.	Early Paleocene	Khadro	1522
11.	Early Cretaceous	Upper Goru	2001.5
12.	Early Cretaceous	Lower Goru	2545

Table 2.1 Stratigraphic column encountered in KADANWARI-01

2.7 BASINS OF PAKISTAN

Sediments get developed at certain place, they may be deposited at the place of their origin or may get transported to other place by transporting agents, and the sediments deposited at the place of origin are called **Molasses,** what happens with the transported sediments? Its answer is that they are often deposited at a place which is characterized by regional subsidence and where they could get preserved for longer periods of time, such a place is called a **Basin,** in a basin the receptacle or container which is the substratum of the basin is called **Basement**, the accumulated sediments in a basin are called **Sedimentary Cover**, the gradual settling of sediments in a basin is called **Subsidence**, the point of maximum sedimentary accumulation in a basin is called **Depocenter.** In terms of the genesis and different geological histories, Pakistan consist upon two major sedimentary basins, the Indus Basin and the Baluchistan Basin, these basins were developed during different geological episodes. There is another smaller basin which has its own geological history of development, this basin was developed due to the collision between India and Eurasia and is classified as the Median basin. It is the **Kakar Khorasan** Basin which is also known as **Pishin Basin**. (See Fig 2.2)

According to Fig 2.2, Indus Basin is divided into the following classes,

1. Upper Indus Basin
   It further has following partition
   (a) Kohat Sub Basin
   (b) Potwar Sub Basin
2. Lower Indus Basin
   It further has following partition
   (a) Central Indus Basin
   (b) Southern Indus basin

2.8Lower Indus Basin

This basin is characterized by passive-roof duplex-type structure and a passive backthrust along the Kirther Fold Belt, a passive roof thrust forming a front culmination wall along the margin of fold belt, and the Kirther depression and out-of syncline intra-molasses detachments in the Kirther depression sequence. The Kirther and Karachi depressions contain several large anticlines and domes and some of these contain small gas fields(Mazarani,Sari,Hundi,and Kothar). The eastern part of basin comprising the Sindh monocline is largely comprised of faulted and tilted blocks of Mesozoic rocks which form structural traps overlain by Deccan Trap Basalts and Tertiary sedimentary rocks .The northern margin of Lower Indus Basin comprises the Sukker Rift on which bears large anticlinal structures and contains the Khandot and Mari Gas fields. The latter is a giant field 6.3 TCF of reserves. The main reservoir rocks in the Sindh Monocline are Cretaceous Lower Goru sandstone. In the Karachi depression production is from Paleocene Ranikot limestone and sandstone, in Kirther depression and Sukker Rift zone it is from Eocene Sui Main /Habibrahi limestone. The lower Indus basin is also characterized by high geothermal gradients which range from 2 to over 4^0C/100m.

2.9 Geologic / Tectonic Boundaries

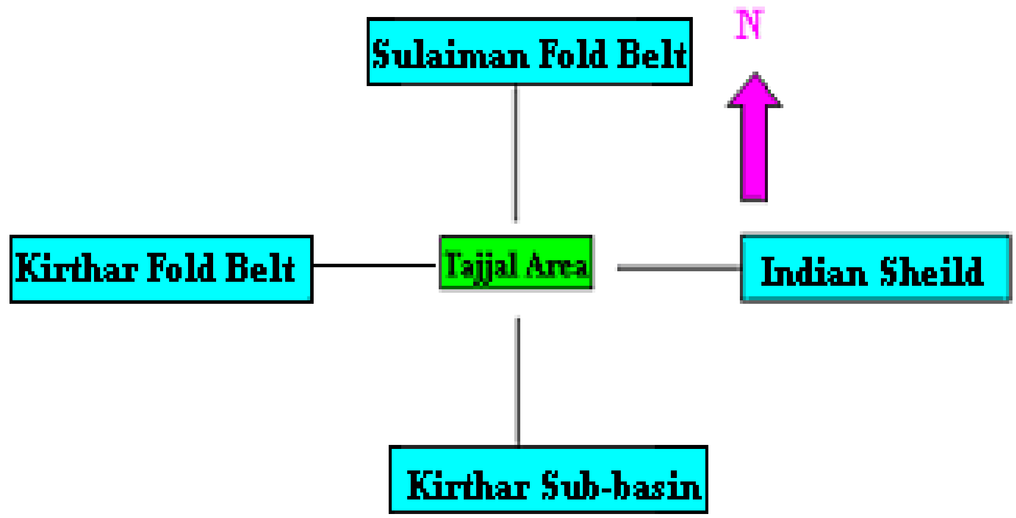


Fig 2.4 Tectonic Boundaries of Tajjal Area

2. 9 Geographic Boundaries

Fig 2.5 Geographic Boundaries of Tajjal Area

2.10 Structure of the Studied Area

Almost all of the lower Goru discoveries are located on near the (mostly east –to southeastward of) one or other structural high (Mari high, Jacob bad khairpur high, Badin uplift, lakhra high, which has implications for the migration pathways, timing of the reservoir charge and hydrocarbon entrapment in structural and subtle stratigraphic features. Most of these structures high are inversion features identified on the regional seismic lines. The first uplift episode occurs near the K-T boundary, and is manifested as the base Tertiary Unconformity. The Paleocene Ranikot clastics thin-out towards and propagade out and thicken away from these highs. Moreover, the majority of deep basement related and shallower wrench –tectonics related faults terminate against this unconformity. Generally, the entire cretaceous section changes character from strongly linear and single fault at top Chilton to multiply an echelon left-lateral segments at lower and upper Goru levels. This tectonic event was a result of trans-tensional tectonics related to first docking of India –Eurasia plates and encounter –clockwise rotation of the Indian plate. The second uplift event in the middle and lower Indus Basin took place during the late Eocene-Oligocene times. The structural high probably underwent recurrent phases of up heaval in response to successive phases of thrust loading in the west and northwest. The final modification of the shapes of traps and potentially the secondary hydrocarbons migration and reservoir charge took place during this period.

2.11 Sember-Goru Petroleum System

The lower Goru play discoveries are located within the platform part of the middle and lower Indus Basin from the Mari High all the way down to the Badin Area. A number of studies exist in the exploration files and public domain (mostly unpublished) that have documented the depositional framework reservoir Stratigraphy of the Lower Goru in this area.A more recent account of the Lower Goru shelf and shelf margin sequences and reservoir facies distribution is presented by Khan, Mughal and Jamil

2.12 Stratigraphy

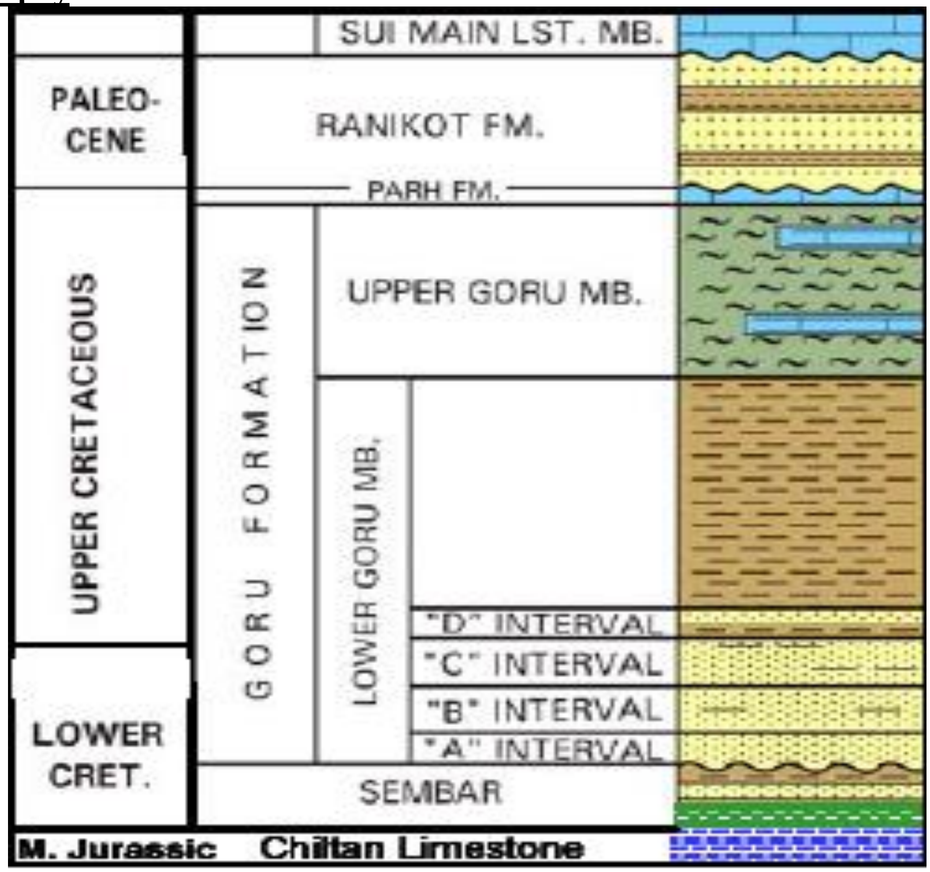


Fig 2.6 Stratigraphy of the Tajjal Area (Ahmed et al, 2004)

According to Fig 2.6 early siliclastics were deposited on the top of an extensive carbonate Platform (Chilton Limestone) that underwent massive and regionally extensive environmental collapse in Kimmeridgian-Oxfordian times as a result of renewed rifting between the Indian and African plates and subsequent drowning. The late Jurassic drowned Unconformity and the Lower Goru condensed section is there fore used to flatten the regional seismic sections on flattening sections on this horizon removes the younger structural relationships in a near depositional form. The prospective sand prone sequences in the Lower Goru play Fairway consist of alternate sandstone shale paralics deposited in deltaic marine strand plain and barrier bar shore face to offshore setting on a ramp. Informally, these units are named as Lower Goru members "A", "B", "C" to "D" intervals. These sedimentary packages were deposited on the top of vast and extensive ramp built by the Sember and "A" and low- stand deposition. A gradual and long- term base level rise (3rd order eustatic or tectonic- eustatic sea level rise), punctuated by high frequency 4rth and 5th order relative sea level fluctuations, and an active northerly to long shore drift and tidal effect (wave-and tide-dominated system) led to the deposition of aggradational to westerly prograding wedges that rarely reached the shelf margin position of ramp built by the Sember and "A" low stand- ramp. The areas close to structural highs works with the westward facies related shale-out of the prograding sand wedges to provide stratigraphic traps.

2.13 Lower Indus Plate Form and Fold- And – Thrust –Belt

2.13.1 Sember Formation

This is the lower most unit of the Cretaceous Sequence in the Kirther-Sulaiman Region, consisting of blocks of shale interbedded with silt stone and nodular, argillaceous lime stone. The shale and silt and are commonly Glauconite. The formation is 133m thick in type area and 262 m thick in the Mughal Kot section. It has a gradational contact with the overlying Goru formation through at places an unconformity had been reported by **Williams (1959).**

2.13.2 Goru Formation:

This formation is composed of interbedded lime stone, shale and siltstone. The lower part is more shaly and consists of very thin-bedded, light- colored lime stone interbedded with thin to irregularly bedded,calcarios , hard , splintery grey to olive- green shale. The upper part is largely thin- bedded, light – colored porcellanneous lime stone with sub ordinate shale. It grates into the overlying parh lime stone. At type locality (Goru Village) the formation is 538 m thick. **Williams (1959).**

2.13.3 Par Lime Stone

This is very uniform distinct and persistent rock formation and exposed extensively in the Kirther – Suleiman region. It is thin – bedded, light grey, white or cream colors with a persistent pink, purple to maroon colored band of interbeds of variegated shales and marls. The limestone is hard, lithographic to porcellanneous, platty to slabby with aconcoidal fracture. In the type area in parh range, the parh lime stone is 268 m thick through elsewhere its thickness ranges from 300 to 600 m. it has a conformable contact with the underlying Goru formation and is overlain conformable by the Mughal Kot formation. **Williams (1959).**

2.13.4 Mughal Kot Formation

This formation consists of grey calcareous shale and mud stone with intercalations of arkosic sand stone and grey argillaceous lime stone. In the Sulaiman area the sand stone is well developed whereas in Kirther area the formation is largely grey, silty calcareous shale. In one of oil wells (Dabbo Creek) near Karachi, basalts are present whereas near Kahan village in Ziarat area the formation is locally contains a thick sequence of conglomerates with boulders and pebbles of basalt; (Kahan conglomerates member of Williams 1959; Bibaai formation of Kazmi 1955, 1979, 1988). The thickness of formation ranges from about 150 m to 1170 m. The type section is 2 to 5 km west of Mughal Kot Post. **Williams (1959).**

2.13.5 Moro formation

This sand stone in the Kirther – Sulaiman region rests conformably and gradationally on the Pab Sand Stone. Where the Pab Sandstone is not developed, the Moro Formation overlies the Fort Munro Formation conformably on the Parh Limestone. It generally consists of a Lower limestone unit, at places with volcanic conglomerates, a missle marly unit with subordinate sandstone and Upper limestone unit. It is overlain conformably by the dungan formation although at places the Khadro formation rests on it disconformably**. Williams (1959).**

2.13.6 Pab Sand Stone

Sand stone is exposed in the Kirther – Sulaiman region. It rests conformably on the fort Munro Formation, but in some localities overlies the Parh Limestone unconformably. It consists mainly of white, cream or brown thick –bedded to massive bedded, cross bedded, medium to coarse grained quarzose, sand-stone with intercalations of subordinate argillaceous limestone and shale. The type section is west of wirahab Nai in the Pab Range where it is 490 m thick, through its thickness ranges from 240 m thick to 1000 m. **Williams (1959).**

2.13.7 Wulgai Formation

This formation is exposed in the Baluchistan Ophiolites-and-thrust belt in Zhob, Kalata and Khuzdar Regions. It has been encountered also in wells drilled in the Lower Indus Basin. It consists of indurated dark grey mudstone and shale with intercalations of thin limestone and calcareous mudstone and sandstone .Previously these rocks were described under different names-Alzoai Group, Shrinab Formation and Winder Group by Hunting Survey Corporation. The thickness of the Wulgai Formation in the type section at Wulgai is estimated at 1180 m, whereas according to Sokolov and Shah the total thickness is 985 m. The Lower contact of the Wulgai Formation with Permian Beds is tectonically described in Wulgai area but it is it is conformable in the Shrinab Section. Its Upper Contact with the Jurassic sequence is transitional **Williams (1959).**.

2.13.8 Shrinab Formation

In the Lower Indus Basin, this Formation is probably the Earliest Jurassic exposed rock unit, ranging in thickness from about 1500 m to 3000 m. It consists of interbedded limestone and shale. According to Fatmi, it is transitional downward and grades into the shaly Triassic Wulgai Formation. Infact the Shrinab Formation of HSC includes undifferentiated Jurassic, Triassic and even Permian rocks. The formation as presently described is early in age and is exposed in Kalat, Queta, Zhob, Loralai Districts of Baluchistan. Equalant rocks in the Khuzdar District have now been renamed Ferozabad Group. Williams (1959).

2.13.9 Chiltan Formation

In the Kalat, Queta ,Sibi and Loralai Districts a massive to thick bedded dark-to-light –grey or cream colored ,sub-litholographic oolitic limestone 750 m to 1800 m thick conformably and gradationally overlies the Shrinab Formation. At places the limestone is reefal or biohermal . it was named Chilton Limestone by HSC and the name was adopted by Fatmi.The type section is along Dara Manda south of Boston. **Williams (1959).**

2.13.10 Mazar Drik Formation

In the Sibi, Kalat and Khuzdar Districts, the Takatu limestone is overlain conformably by the Mazar Drik Formation, which consists of interbedded grey limestone and dark shale. The type area is Mazar Drik where the formation is about 30 m thick. **Williams (1959).**

2.14 Eocene System Williams (1959).

2.14.1 Pab Sandstone

This sandstone is exposed in the Kirthar-Sulaiman region. It rests conformably on the Fort Munro Formation, but in some localities overlies the Parh Limestone unconformably (Shah 1987). It consists mainly of white, cream or brown thick-bedded to massive, cross-bedded, medium- to coarse-grained quartzose, sandstone with intercalations of subordinate argillaceous limestone and shale.The type section is west of Wirahab Nai in the Pab Range where it is 490 m thick, though its thickness ranges from 240 m (Mughal Kot) to 1,000 m.

2.14.2 Khadro Formation

It is widely distributed in the Kirther and adjacent region, lies unconformably on the laki Cretaceous Pab sandstone and Moro Formation. The type locality is Bara Nai in the Laki Range. At the type locality, the badalpart of formation consists of limestone containing oysters and reptiles bones. The thickness of the Formation is test holes at Lakhra and Dabbo Creek, thickness of 140 m and 180 m were penetrated.

2.14.3 Bara Formation

This Formation conformably overlies the Khadro Formation and is wide!y distributed in the Kirthar Range and adjacent areas. The type section is in Bara Nai in Lakhi Range. The Formation consists of interbedded sandstone and shale. The sandstone is fine- to coarse-grained, calcareous, ferruginous and at places glauconitic, ripple-marked and cross-bedded. Beds range in thickness from a few centimetres to over 3 m. The shale is soft, earthy, gypsiferous and commonly carbonaceous.

2.14.4 Lakhra Formation:

It overlies the Bara Formation and crops out in, the Kirthar and adjacent areas. The type section is in the southern part of the Lakhra anticline. It consists mostly of grey, thin- to thick-bedded, nodular, sandy and in places, argillaceous, fossiliferous limestone, with interbeds of sandstone and shale in the upper part. Its thickness ranges from 50m to about 242 m.

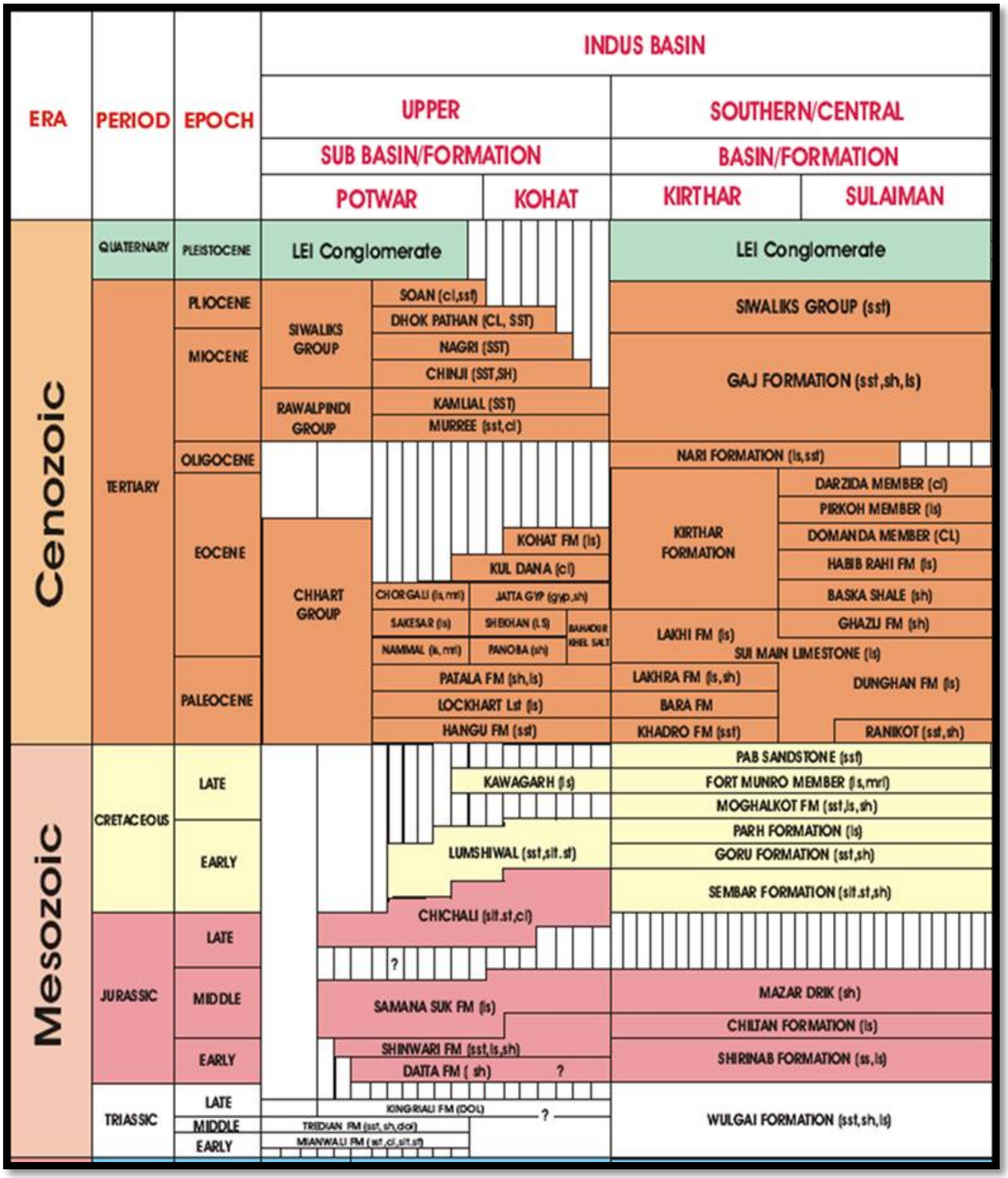


Fig.2.7 The division of stratigraphic section, their ages and rock types of Lower Indus Basin.(Iqbal Qadri)

CHAPTER # 3

SEISMIC METHOD

3.1 Introduction to Seismic Methods

Seismic method is one of the most commonly used geophysical techniques for investigating the subsurface. The predominance of the Seismic method over other geophysical method is due to various factors, the most important of which are the high accuracy, high resolution and great penetration of which the method is capable. The widespread use of seismic method is principally in Exploration of petroleum.

The basic technique of seismic exploration consists of generating Seismic waves and measuring the time required for the waves to travel from the source to a series of geophones usually disposed along a straight line directed towards the source.

If the rock layers are horizontal or gently dipping seismic waves follow uncomplicated path. The two kinds of paths are followed by reflection seismic waves and refraction seismic waves.

The reflected waves have traveled downward to borders between rock layers where they bounce or echo back to the surface. In contrast, the refracted waves follow paths that bend at each border. **(Robinson & Coruh, 1988)**

Energy sources are used to generate the seismic waves, which penetrate the earth's crust and undergo reflection and refraction at different elastic discontinuities. An array of geophones is used to detect them, which are infect, one of electromechanical devices capable of converting the up and down motion of ground into electrical signals. The data is usually recorded on magnetic tape, or any other medium.

In seismic method actually a relation is developed between the Seismic velocity and the subsurface lithology. The results obtained are interpreted in geological terms and the lithology of subsurface is studied.

3.2 Type of Seismic Methods

There are two types of seismic methods:

3.2.1 Reflection Method

The Seismic reflection method in fig(3.1) is based on the study of elastic waves reflected from the interface between the geological layers. This method is base on Law of reflection which is that when a wave is propagating through a medium. It bounces back with the same angle in which it incident. This is very useful in oil exploration finding out deep structure such as anticline, salt domes and trusted anticlines. This method is preferred on other geophysical method because it has long penetration in subsurface.

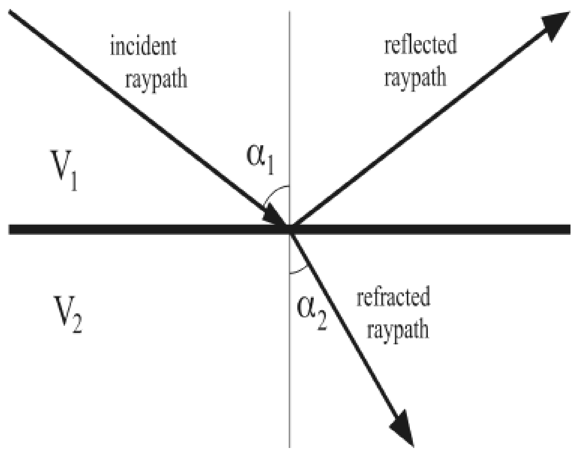


Fig3.1 Reflection method

3.2.2 Refraction Method

The Seismic Refraction method is based on the study of the elastic waves refracted along the geological layers in which the velocity of propagation of elastic waves is greater than the overlying strata. This method is base on Snell's law show in fig(3.2) which is when wave is incident in a medium some part of it is bounces back while the other is transmitted to another medium

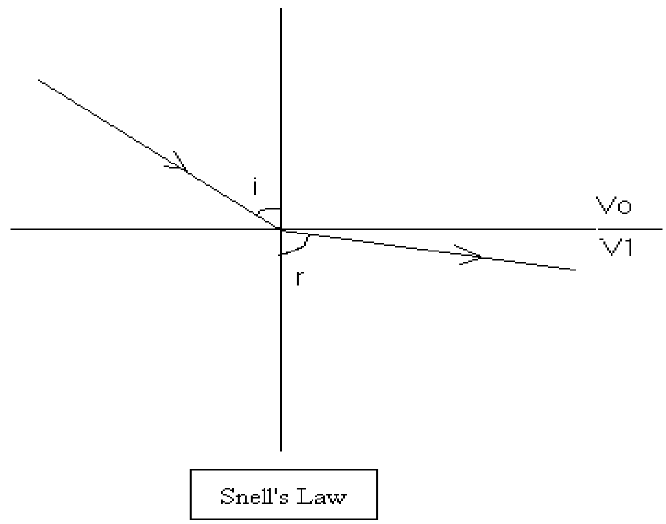


Fig3.2 REFRACTION METHOD

3.3 Applications of Seismic Methods

Seismic methods are used

- To find out the structural traps (such as anticlines, faults, salt domes and reefs).
- To investigate the Stratigraphic features like discontinuous layers.
- Reflection data can be used to determine the average velocities of seismic waves provide a good indication of Lithology. **(Dobrin and Savit, 1988)**
- Seismic method is also used in search for ground water, in civil engineering, mineral exploration and locating subsurface features. **(Robinson and Coruh, 1988)**

3.4Types of Seismic Waves

Seismic waves are messengers that convey information about the earth's interior. Basically these waves test the extent to which earth materials can be stretched or squeezed some what as we can squeeze a sponge. They cause the particles of materials to vibrate which means that passing seismic waves temporarily deforms these particles can be described by its properties of elasticity. These physical properties can be used to distinguish different materials. They influence the speeds of seismic waves through those materials.

These waves are generated by Earth's material as a result of an earthquake or an explosion. Seismic waves are of two types; the body waves and surface waves. When a stress is suddenly applied to an elastic body or when stress is suddenly released the corresponding displacement is propagated outward as an elastic wave. Different types of propagation give rise to different waves. So seismic waves can be divided into two parts,

1) Body waves

2) Surface waves

3.4.1Body Waves

These are those waves, which can travel though the earth interior and provide vital information about the structure of the earth. The body waves can be further divided into the following;

- P- waves (Primary waves)
- S- waves (Secondary waves)

- **P –waves (Primary Waves)**

The particular kinds of waves of most interest to seismologists are the compressional or P-waves also called as compressional waves, longitudinal waves, primary waves, pressure waves, and dilatation waves **(see Figure 3.3)**. In this case the vibrating particles move back and forth in the same direction as the direction of propagation of waves. P-waves can pass through any kind of material - solid liquid or gas. The P-waves velocity depends upon density and elastic constants. **(Dobrin and Savit, 1988)** The seismic velocity of a medium is a function of its elasticity and can be expressed in

terms of its elastic constants. For a homogeneous, isotropic medium, the seismic P-wave velocity Vp is given by;

$$Vp = \sqrt{\frac{(4/3)\mu + k}{\rho}} ,$$

Where μ is the shear modulus, k is the bulk modulus and ρ is the density of the medium.

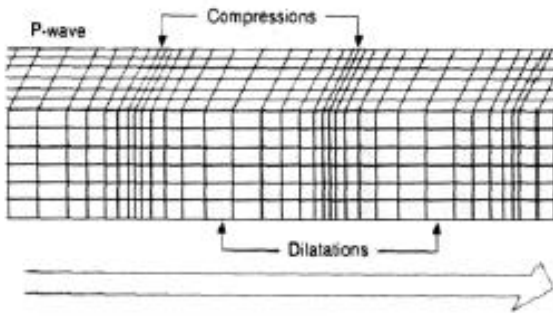


Fig 3.3 Propagation of P-waves in an elastic medium

- **S waves (Secondary waves)**

In shear waves, the particles vibrate in a direction perpendicular to the direction of propagation of waves.show in (3.4)

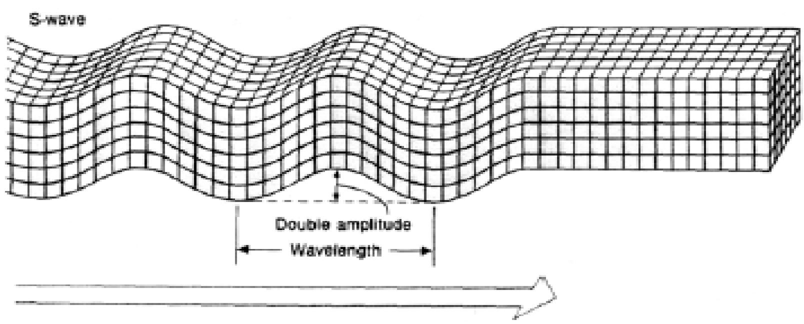


Fig 3.4 Propagation of S-waves in an elastic medium

They are also called as shear waves, transverse waves, and converted waves. For ideal gases and liquid μ=0. S-waves cannot pass through fluids (Dobrin and Savit, 1988). The velocity of S-waves is given by (using the same notation as of V_p);

$$Vs = \sqrt{\frac{\mu}{\rho}} .$$

Characteristics of Body Waves

These travel with low speed through layers close to the earth's surface, as well in weathered layers. (Robinson & Coruh, C, 1988)

Frequency of body waves in exploration vary from 15Hz to 100 Hz . (Parasnis, 1997).

3.4.2 Surface Waves

A part from body waves more complicated patterns of vibration are observed as well. These kinds of vibrations can be measured only at locations close to the surface. Such vibrations must result from waves that follow paths close to the earth's surface, hence known as surface waves.

In bounded elastic solid, surface waves can propagate along the boundary of the solid. Frequency of surface waves is less than 15Hz (Parasnis, 1997). Surface waves are also of two types;

- Raleigh waves
- Love waves

- **Love Waves**

A type of surface waves having a horizontal motion i.e. transverse to the direction of propagation (Kearey, Brooks & Hill, 2002). The velocity of these waves depends on the density and modulus of rigidity and not depends upon the bulk modulus (k). Show in

Fig(3.5)

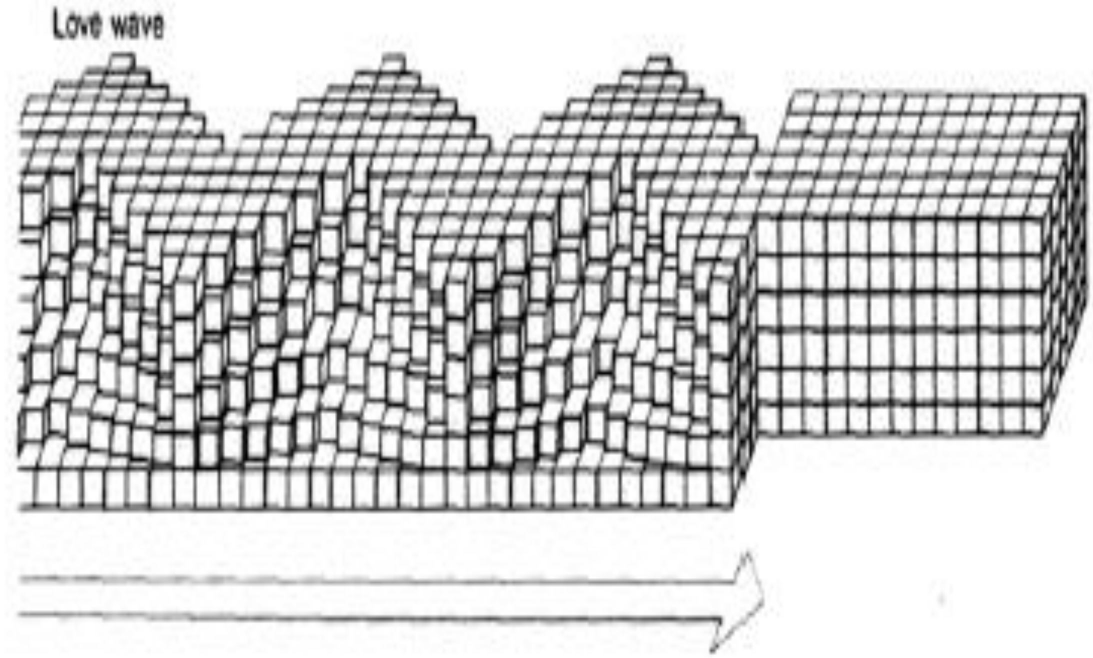


Fig 3.5 Propagation of Love waves in an elastic medium

- **Raleigh Waves**

Type of surface waves having a retrograde,in Fig(3.6) elliptical motion at the free surface of a solid and it is always vertical plane. Raleigh waves are principal component of ground roll (Kearey, Brooks & Hill, 2002).

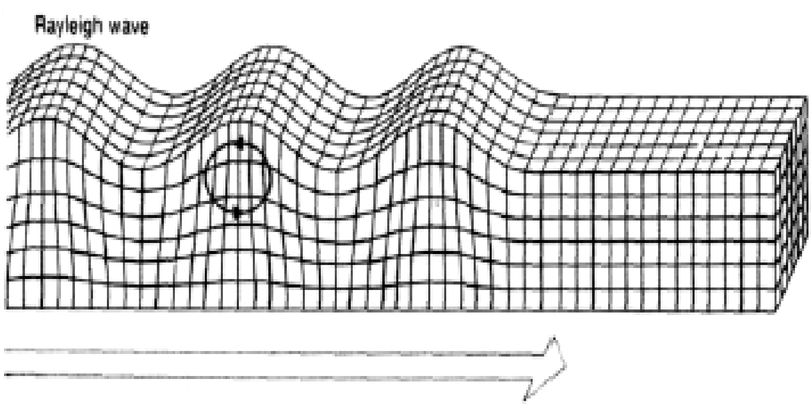


Fig3.6 Propagation of Raleigh waves in an elastic medium

3.5 Basic Laws Seismic Waves

- **Theory of Elasticity**

The seismic method utilizes the propagation of waves through the earth, since this propagation depends upon the elastic properties of the rock so it is necessary to know the elastic properties of the subsurface material.

The size of a solid body can be changed by applying forces to the external surface of the body. These external forces are opposed by internal forces, which resist the changes in size and shape. As a result, the body tends to return to its original condition when the external forces are removed. Similarly, a fluid resist changes in size (volume) but not changes in shape. This property of resisting changes in size or shape and of returning to the undeformed condition when the external forces are removed is called elasticity.

Stress

"The force (F) applied per unit area (A) of the body"

Its unit in SI system is Pascal and one Pascal is equal to one Newton per square meter. Mathematically;

Stress = F/A

Strain

Strain can be defined

> "As the change in size and shape of the body when external forces are applied on that body"

These changes are called Strain. It has four types.

- Longitudinal Strain
- Transverse Strain
- Shear Strain
- Dilation

Hooke's Law

This law states that

” Stress is the directly proportional to strain provided the elastic limit of the body is not exceeded. This limiting value depends upon the nature of rock body”.

Mathematically

Stress α Strain

Elastic Modules

The linear relationship between stress and strain in the elastic filed is specified for any material by its various elastic modules, each of which expresses the ratio of a particular type of stress to the strain and provides a measure of rigidity. There are certain types of elastic modules as given below;

- Bulk Modulus
- Shear Modulus
- Young's Modulus
- Poisson's Ratio

➢ **Bulk Modulus (K)**

It is the ratio of stress to the volumetric strain and is given by the relation

$$K = \frac{\text{volume stress}}{\text{volume strain}} = \frac{P(\text{pressure})}{\Delta V/V}$$

.

Mathematically it can be represented as,

$$k = \frac{1}{\kappa} = \frac{P}{\Delta V / V}$$

Where k is the compressibility coefficient

- **Shear Modulus (μ)**

The shear modulus is defined as

"The ratio of shearing stress "τ" to the resulted shear strain "tanθ". It is also called as rigidity modulus. It is denoted by "μ". For liquids and gases, shear modulus (μ) is zero

$$\mu = \frac{\text{shear stress}}{\text{shear strain}}$$
$$= \frac{F/A}{\tan\phi}$$
$$= \frac{F/A}{\Delta L/L}$$

Mathematically it can be represented as (where τ is the shear stress);

$$\mu = \frac{\tau}{\tan\theta}$$

- **Young's Modulus (E)**

It is defined as the

"The ratio between longitudinal stress and longitudinal strain. It is also called stretch modulus". It is denoted by "E"

$$E = \frac{\text{longitudinal stress}}{\text{longitudinal strain}}$$
$$= \frac{F/A}{\Delta L/L}$$

- **Poisson's Ratio (σ)**

It is used to show that the change in diameter (d) is proportional to the change in length (l). Poisson's ratio varies from 0 to ½ and has the value ½ for fluids.

$$\sigma = \frac{\text{transverse strain}}{\text{longitudinal strain}}$$
$$= \frac{\Delta D/D}{-\Delta L/L}$$

Mathematically it is represented as Bulk modulus (k) and Shear modulus (μ);

$$\sigma = \frac{3k - 2\mu}{2(3k + \mu)}$$

Relationship between Elastic Module

The all four module can be interrelated in the following way (Dobrin and Savit, 1988)

K=E / 3(1-2σ)

μ =E / 2(1+ σ)

3.6 Laws governing seismic waves

There are three fundamental laws that govern the seismic wave propagation.

1) Huygen's principle
2) Fermat's principle
3) Snell's law

1) Huygens's Principal

> "Every point on a wave front is a source of new wave that travels away from it in all directions"

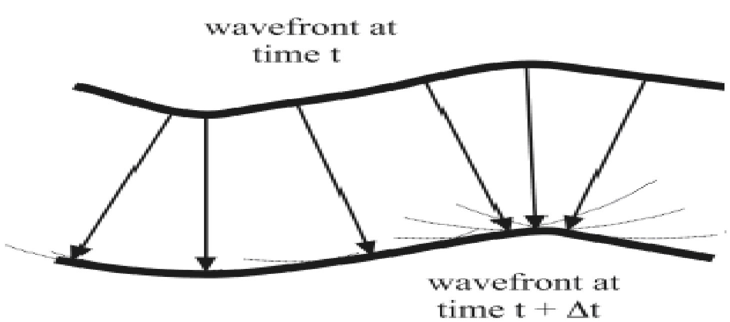


Fig 3.5 Huygens's Principle

2) Fermat's Principal

It states that

> "Elastic waves travel between two points along the paths requiring the least time"

3) Snell's Law

According to this law

> "Direction of refracted of reflected waves traveling away from a boundary depends upon the direction of the incident waves and the speed of the waves"

Mathematically,

$$\frac{\sin(\alpha_1)}{V_1} = \frac{\sin(\alpha_2)}{V_2},$$

Where V_1 and V_2 are velocities in the upper and lower layers, α_1 is the angle of the incident ray-path with respect to the vertical, and α_2 is the angle of transmission of the refracted ray-path with respect to the vertical.

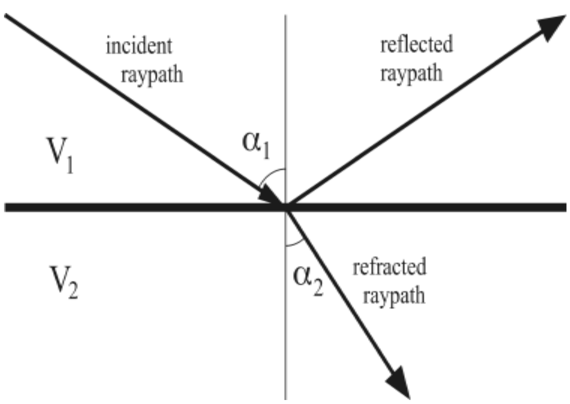


Fig 3.7 Refraction and reflection of an incident wave

3.7 Reflection- and transmission-coefficients

The Reflection- and Transmission coefficient give the ratio between the incident amplitude A_0 and the reflected (A_R) and transmitted (A_T) amplitude, respectively. In the special case of a incident wave perpendicular at an interface for a P-wave, a simple expressions for the reflection and transmission coefficient is obtained.

3.7.1 Reflection coefficient

These coefficients compare the amplitude of incident wave and reflected wave. Value of reflection coefficient varies from -1 to +1(Khan, 1989). For R=0, there will be no reflection, wave will be transmitted. It can be mathematically represented as;

$$R = \frac{A_R}{A_0} = \frac{v_2\rho_2 - v_1\rho_1}{v_2\rho_2 + v_1\rho_1} = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$

3.7.2 Transmission coefficient

Transmission coefficients are those, which compare the amplitude of incident wave and refracted wave. Value of transmission coefficient varies from 0 to2 (Khan, 1989).

If Ai is the amplitude of incident wave and At is the amplitude of transmitted wave, then transmission coefficient T is given as follow;

$$T = \frac{A_T}{A_0} = \frac{2v_1\rho_1}{v_2\rho_2 + v_1\rho_1} = \frac{2Z_1}{Z_2 + Z_1}$$

The product Z = v ρ is known as the acoustic impedance.

Reflection and transmission in terms of energy

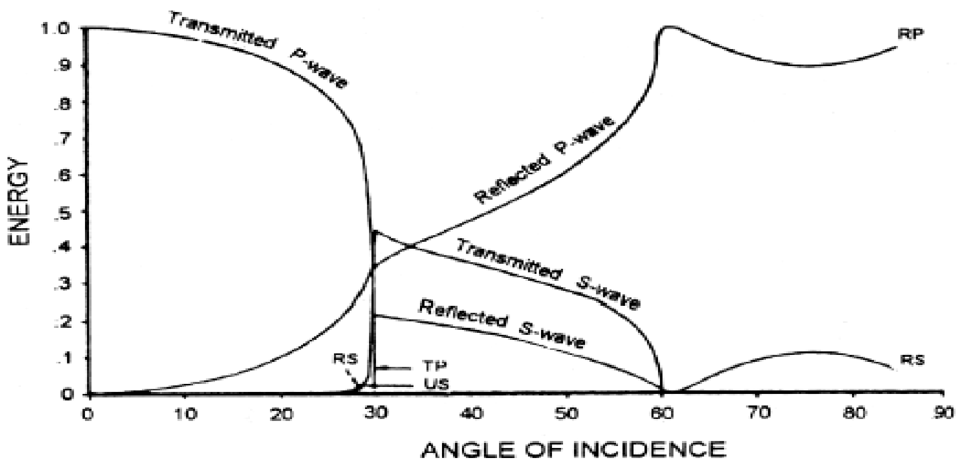
Sometimes the coefficients, which describe the energy and not the amplitudes, are introduced as Reflection- and Transmission coefficients see in fig (3.8)

Reflection coefficient in terms of energy see in fig (3.8)

$$E_R = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$$

Transmission coefficient in terms of energy see in fig (3.8)

$$E_T = \frac{4Z_1Z_2}{(Z_2 + Z_1)^2}$$



Fig(3.8) Angle dependent reflection and transmission coefficients for P and S-waves

3.8 Wave Conversion

When a wave reaches the boundary between two substances having velocities, it divides up into waves that reflect from the boundary or refract across the boundary. So an incident wave is converted into reflected and refracted waves. An incident wave can be P-wave, S_V-wave or S_H-wave. (Robinson & Coruh, 1988)

- When incident wave is P-wave then it is reflected and refracted as P-wave and S-wave as shown in fig 3.9a
- When incident wave is S_V-wave then it is reflected and refracted as P-wave and S_V-wave shown in fig 3.9b
- When incident wave is S_H-wave then it is reflected and refracted as S_H-wave shown in fig 3.9c

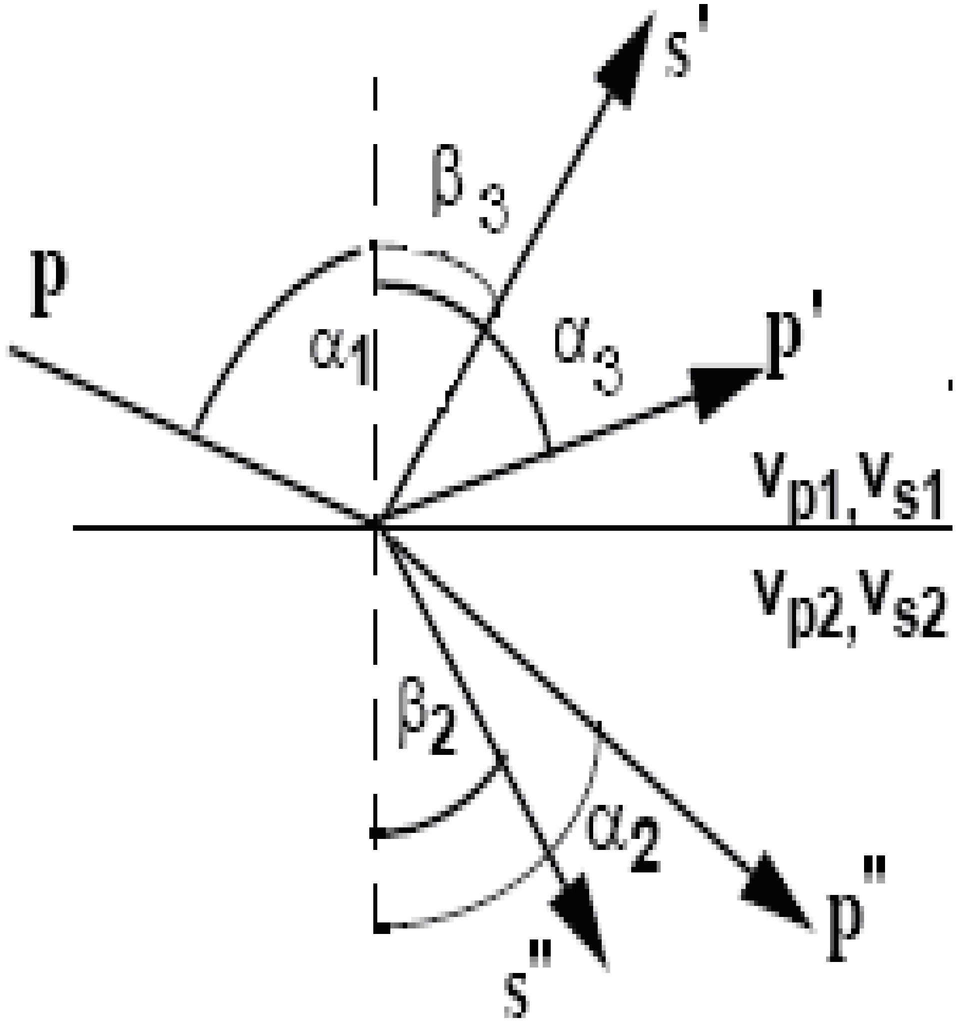


Fig 3.9a Wave conversion of P-wave into various waves

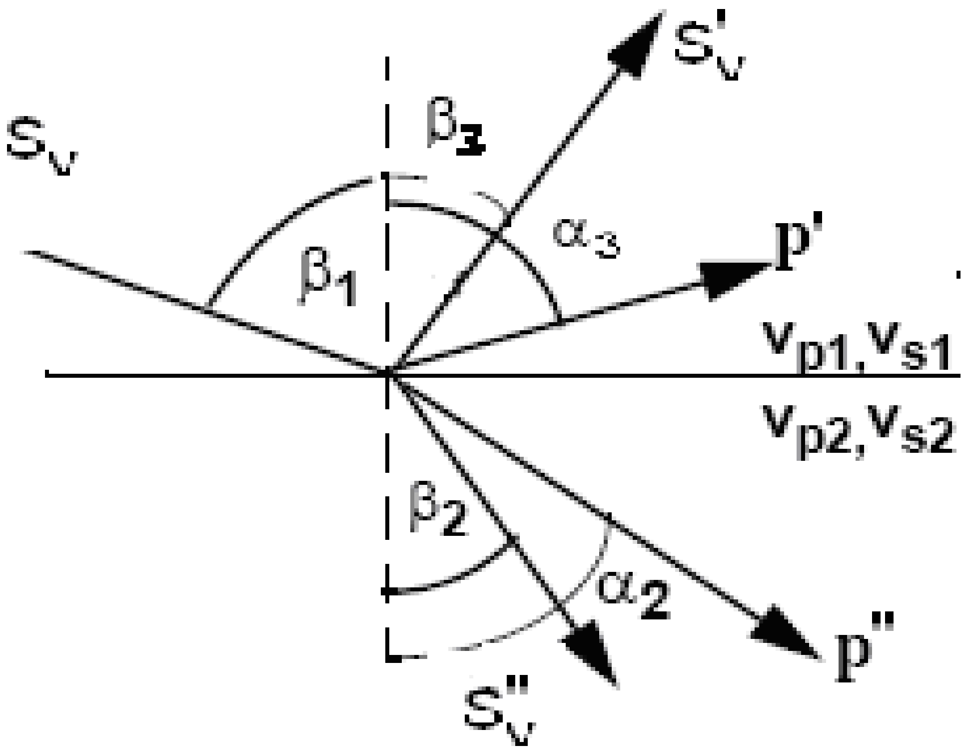


Fig 3.9b Wave conversion of S_V-wave into various waves

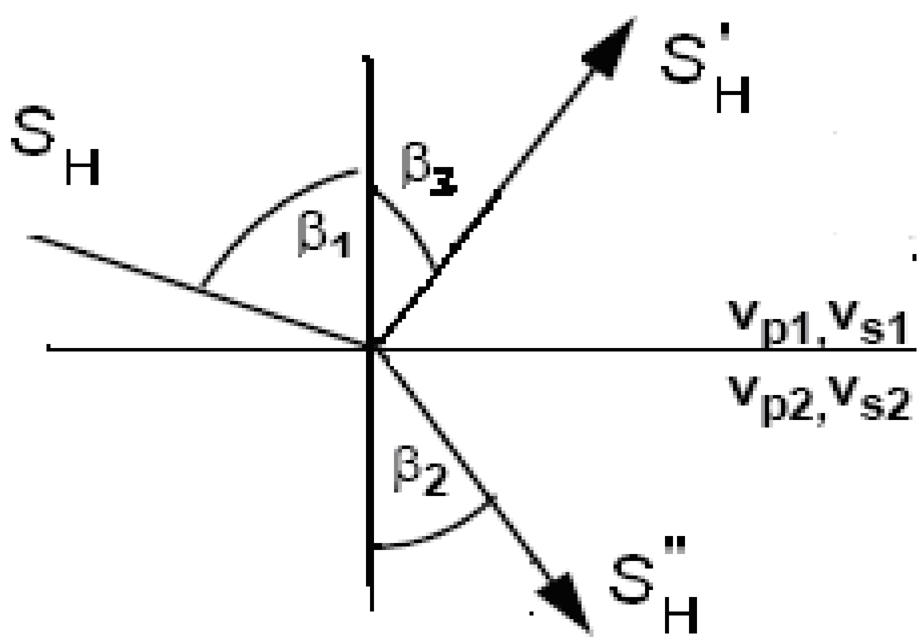


Fig 3.9c: Wave conversion of S_H-wave into various waves

3.9 SEISMIC METHOD

Seismic technique is a standout amongst the most critical geophysical strategy in every geophysical technique. This prevalence is a direct result of different variables i.e. its high exactness, high determination and extraordinary entrance. This wide seismic technique is for the most part utilized as a part of investigation of oil. This essential method of seismic investigation is that seismic waves are produced and the time required for waves to go from source to the geophones which are orchestrated in particular example is measured. There are two sorts of seismic techniques i.e.

3.9.1 SEISMIC REFLECTION METHOD

The seismic reflection strategy depends on the examination to outline geographical structures. Estimations are set aside a few minutes of occasions credited to seismic waves which have been reflected from interfaces where the acoustic impedance changes. The target for the most part is to outline in the profundity and state of mind of the interfaces which as a rule are parallel to the bedding.

3.10 SEISMIC DATA ACQUISITION:

Seismic examination begins in the field with the procurement of information. The motivation behind seismic information securing is to record the impacts created by mechanical unsettling influence at the surface of earth, and its belongings are seen at number of areas along the surface in a way that its connection with beginning aggravation can be deciphered. It incorporates each one of those means which yield last yield to be prepared and translated. The instruments so embraced to obtain seismic information now-a day's contrast from those utilized as a part of past, however fundamental guideline for all instruments is same. The seismic information procurement begins with, field by few association partitioned as though it is arrive association or marine association. At that point the entire work begins with field hardware and strategies to be received for the procurement of seismic information. Seismic procurement framework comprises of three fundamental subsystems:

i) Energy sources

(Explosives),

ii)Energy getting units (Geophones),

iii) Recording framework

Explosives or vibrating plates produce the waves and a line or network of geophones records them. Thickness changes between shake or soil layers mirror the waves back to the surface and the speed and quality that the waves are reflected back demonstrates what geographical components lie beneath.

3.11 SEISMIC DATA PROCESSING: The procedure of information handling incorporates the grouping of operations. As per predefined program these operations are done to change over arrangement of crude information into helpful data. Headway of innovation/electronic PCs in most recent two decades acquired the computerized transformation seismic prospecting for oil and gas. After the presentation of PCs seismic information preparing achieved new shape. Figure 3.1 demonstrates the summed up preparing stream graph for seismic information processing.The method of reasoning behind the seismic information handling is to change over the recorded data of field into a frame that permits topographical elucidation, the reflections introduction with greatest conceivable determination on the seismic segment and the diminishment or disposal of various clamors. The fundamental destinations of the seismic information handling are condensed as beneath.

i. Improving Signal to Noise proportion.

ii. Representation of geography in seismic cross-area.

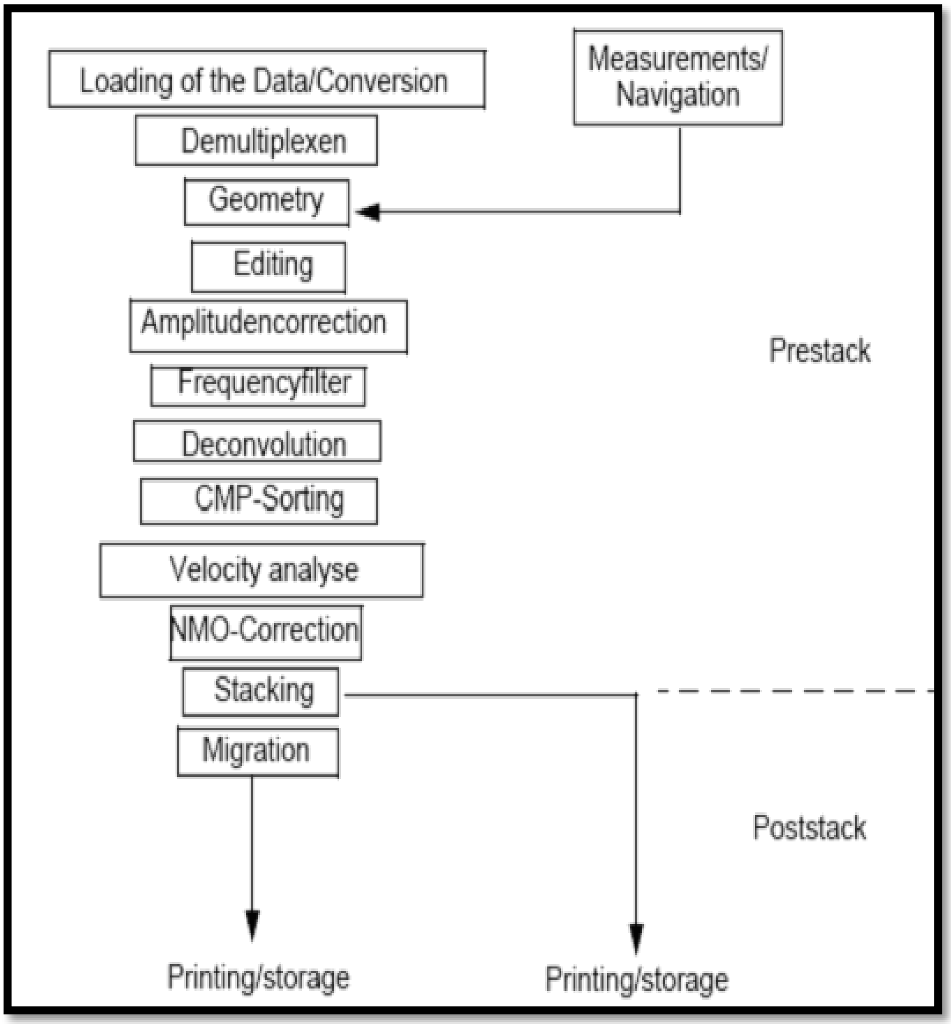


Figure 3.1 Generalized handling stream graph for seismic information preparing.

CHAPTER 4 INTERPRETATION

4.1 INTRODUCTION:

Subsurface basic investigation intends to break down the structure where it counts the earth surface. Geophysicist rehearse this examination to discover the most plausible structure for hydrocarbon aggregation. For subsurface auxiliary examination, these are two strategies:
i)Correlation and

ii) Seismic Interpretation.

In this thesis Seismic interpretation has been finished with the assistance of Seismic Micro Technology (SMT) i.e. Kingdom 8.6

4.2 SEISMIC INTERPRETATION:

Interpretation is the change of seismic reflected information into an auxiliary picture by the use of revisions, relocation and time depth transformation (Dobrin and Savit, 1988).Interpretation of seismic information is extremely confused process including numerous issues and troubles in light of the fact that each region is not the same as different ones, so the approach utilized before most likely would not take a shot at the new range. For this reason, a translator needs to get truly acquainted with a range to work it well and attempting a certain something and after that another is a fantastic approach to truly know the region. The significance of seismic work in the investigation for oil is prove by its broad application. All the real oil organizations depend on seismic understanding for choosing the destinations for exploratory oil wells **(Telford et al. 1976).**

4.2.1 METHODS OF INTERPRETATION:

There are two principle approaches for the Interpretation of the seismic reflection information.

i)Qualitative Interpretation

ii) Quantitative Interpretation.

4.2.2 QUALITATIVE INTERPRETATION:

The essential point of the subjective elucidation of the seismic information is to delineate subsurface topography. Subjective translation is customary or conventional seismic system that incorporate the stamping of along the side reliable reflectors and ends qualities and their mapping on various scales (space and travel time). The geometry on the seismic area is accurately translated in perspective of the land idea to distinguish the hydrocarbon collection. The structure and stratigraphic design of the oil is resolved and in the interest of the geometric elements the area of the well is built up. Stratigraphy examination includes the portraying the seismic groupings, which introduce the diverse depositional units, perceiving the seismic facies trademark which propose depositional condition and investigation of the reflection trademark variety to find the both stratigraphy change and hydrocarbon depositional condition **(Sheriff, 1999).**

In auxiliary examination fundamental emphasis is on the basic traps in which structural assumes an essential part. Structural setting generally represents which sorts of the structure are available and how the basic components are related with each other, so structural of the territory is useful in deciding the basic style of the range and to find the traps. Auxiliary traps incorporate the deficiencies, folds anticline, fly up, duplex, horsts and grabbons structures, and so forth. **(Sheriff, 1999).**

4.2.3 QUANTITATIVE INTERPRETATION:

Seismic quantitative translation procedure when contrasted with the conventional seismic Interpretation strategy is more valuable. One of the upside of these eccentric procedures is that they make prospect era less demanding by extending the investigation zone. Different modifications in these systems have added to the better prospects assessment and repository portrayal. The most essential of these procedures incorporate post-stack sufficiency examination (brilliant spot and diminish spot investigation), off set-subordinate plentifulness examination (AVO investigation), acoustic and flexible impedance reversal, and forward seismic demonstrating. Seismic Interpretation Workflow for seismic information understanding is given in **figure 4.1.** Base map is set up by stacking route and SEG-Y information in programming. Horizon of intrigue are checked physically. In this procedure shortcomings are recognized and checked. Fault polygons are created and horizon are formed to discover basic highs and lows. At that point time and depth shapes are plotted.

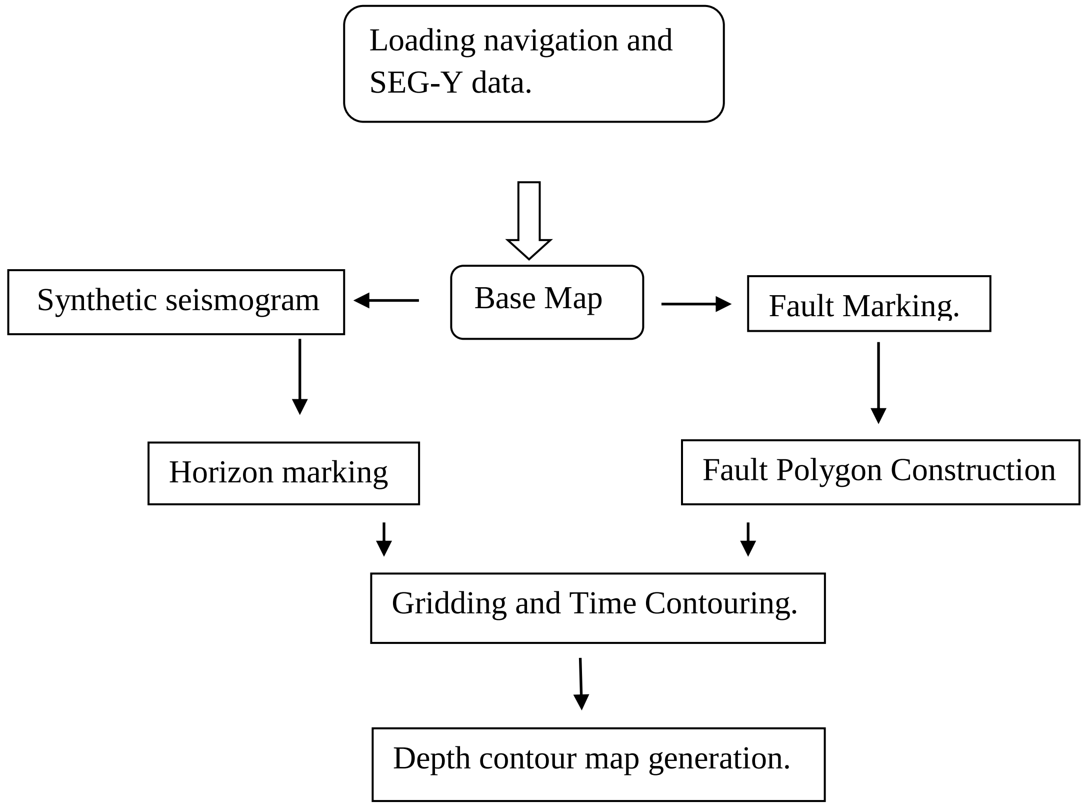
4.3 STRUCTURAL INTERPRETATION OF TAJJAL AREA:

Seismic review is directed to gain information for subsurface investigation. Seismic Interpretation of Tajjal region includes 10 Seismic Lines. These lines have been translated by stamping two horizon (Upper Goru and Lower Goru). Understanding of these seismic lines indicate straight intermittence. The catching mechanics in Lower Indus Platform bowl store rocks have colossal stores of hydrocarbons and the tectonics adjustment of the bowl has framed assortment of trap structures. The repository rocks which are saved are permeable and penetrable rocks. They are available in carbonates and sandstones, while the sources rocks are all Shally in nature.

4.3.1 METHODOLOGY OF INTERPRETATION:

Interpretation of Seismic data must follow following steps:

i. Preparation of base map.
ii. Generation of synthetic seismogram.
iii. Fault identification and marking.
iv. Horizon marking.
v. Interpretation.



Work flow chart for seismic interpretation is given in figure 4.1

For the era of engineered seismogram two route time for each well top is required. Two path time for each well top or reflector is figured by utilizing depth, sonic log information of well and substitution speed of the zone. By utilizing two route time against each well top depth time graph is readied. And after that at long last manufactured seismogram is produced **figure 4.2**. tie this engineered seismogram with the Seismic line, on which well is found (KADANWARI-01). Really seismic information is given in time scale and well tops are given top to bottom so we can't check horizon in time shape. Thus, the motivation behind era of manufactured is to discover two way travel time against every depth for stamping of horizon. With the assistance of this manufactured seismogram two horizon were set apart on line. Tie stamped Seismic with different lines and horizon are set apart on these lines. Amid tie lines mistier move is connected. I have been allocated with four Seismic lines which are deciphered in following segment.

4.3.2MARKING OF HORIZONS AND FAULTS:

The time section gives the position and configuration of reflectors in time domain. But the most important phenomena is fault marking along these seismic sections after which reflectors are marked on given data. After looking into the structural geological maps and tectonic activity maps, we are able to understand the tectonic regime i.e. extensional. So depending on which we have marked few major normal faults on the seismic section.

For marking the horizon we need to identify the major reflectors and in our case our focus was on the petroleum play of the area thus a few reflectors has been marked. For the identification of reflectors we first use the simple method of seismic to well tie. For this purpose the well Kadanwari-01 has been used. We loaded the velocity data along with the well to tie the well with the seismic. After identification of major reflectors we further confirmed those reflectors by generation synthetic seismogram of the Kadanwari-01 well.

4.3.3 SYNTHETIC SEISMOGRAM AND TIE FORMATION TOPS

For the generation of synthetic seismogram we need two major curves i.e. DT and RHOB. Acoustic Impedence was calculated using the above described curves and finally the synthetic seismogram see in fig (4.2) is generated by convolving reflectivity series with the Klauder wavelet.In the figure 4.3. tie this synthetic seismogram is showing the conformity of the formation tops.

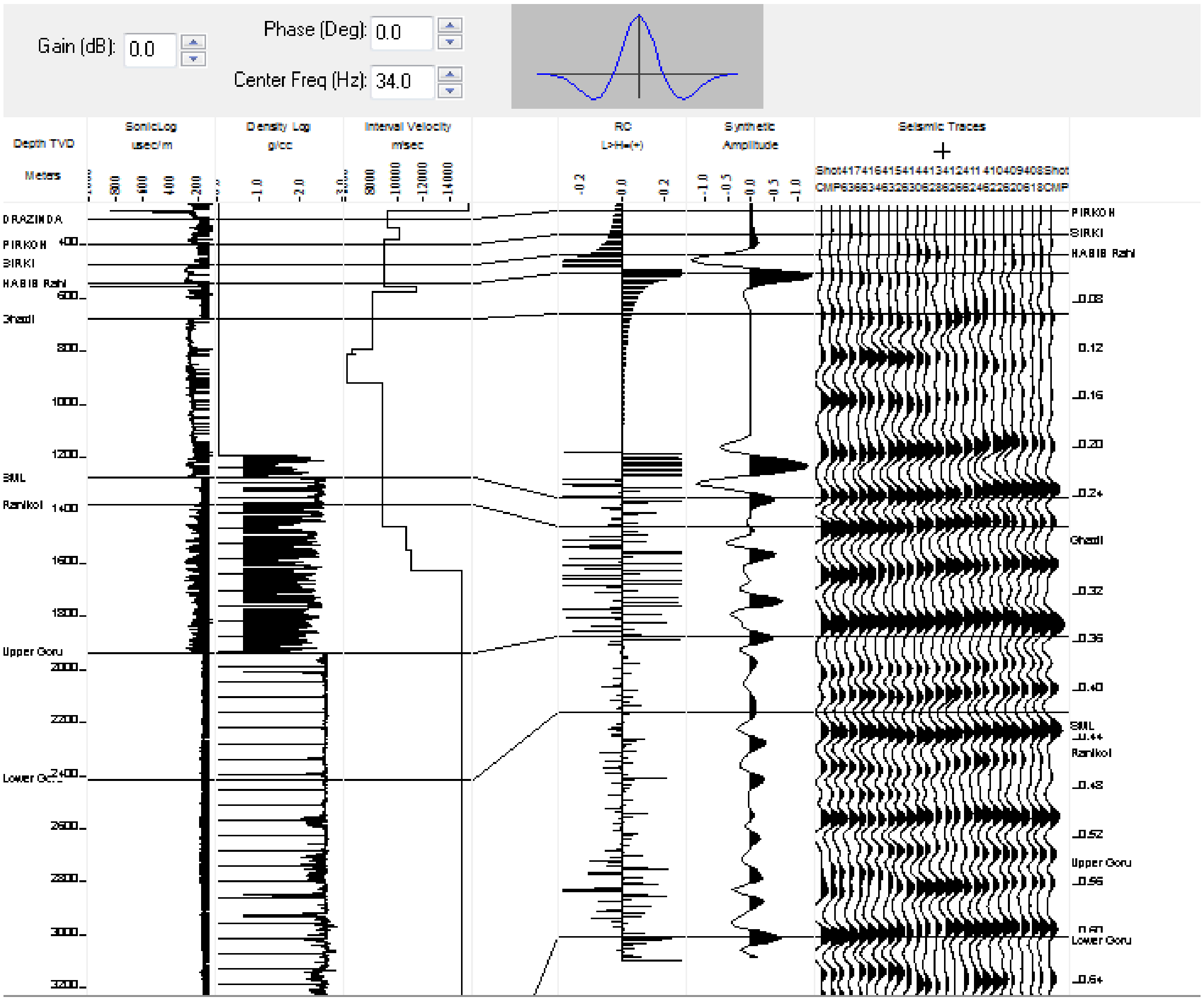


Fig. 4.2: Synthetic seismogram of Kadanwari-01

After generating the synthetic seismogram it is shown along the well as shown in the figure. (4.3)

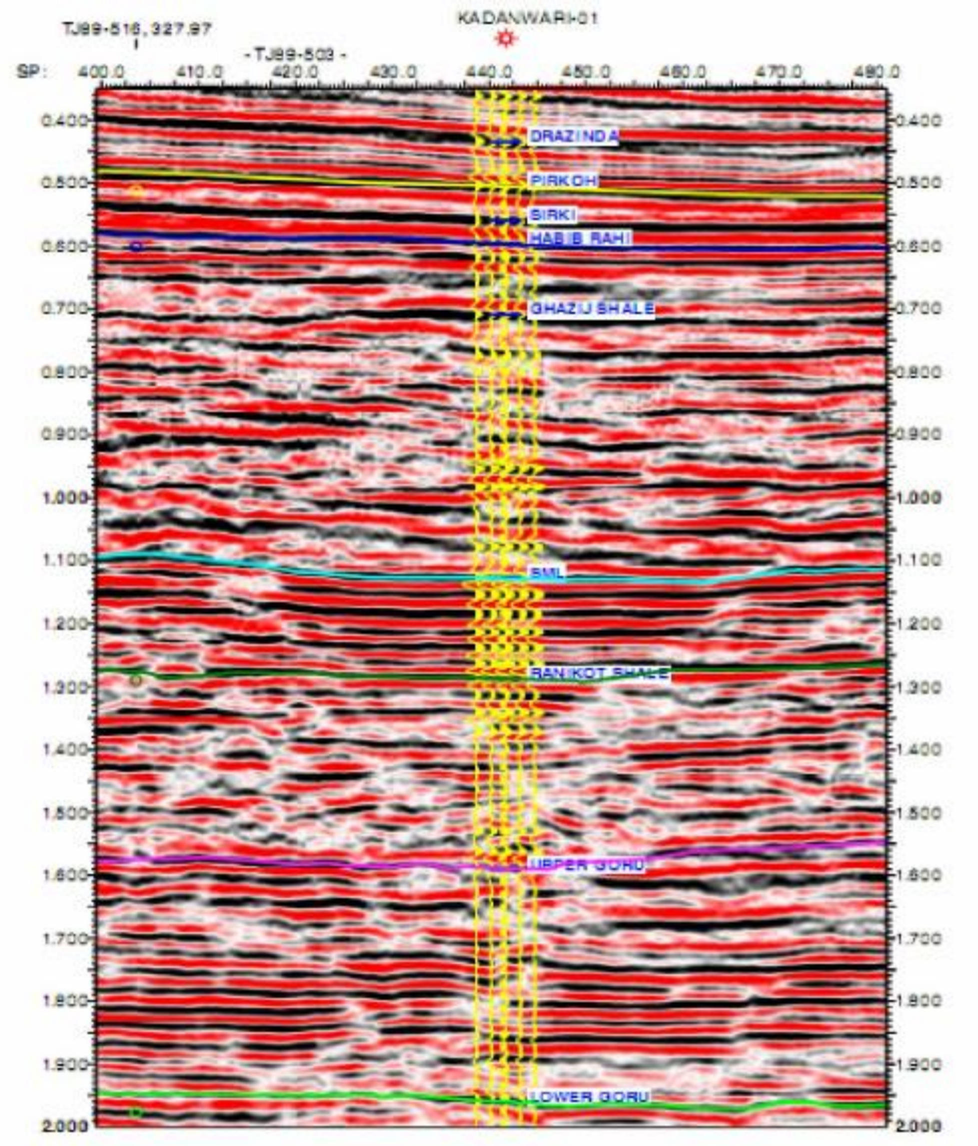


Fig. 4.3 synthetic along Well conforming Well Tops

I have been provided by four seismic lines among which 3 are the dip lines and one is strike line. Well Kadanwari-01 is near to the strike line GTJ89-503 so this line is considered as the key line.

4.4 Seismic line GTJ89-503

Figure 4.4 is NW-SE plunge arranged seismic lines TJ-503, demonstrating checked horizon (Lower Goru, SML and Ranikot) ended by typical faults stamped horizon. The subsurface structures are identified with ordinary blames in East and West with little toss. The example of seismic reflections from the strata inside the bowl recommends that the procedures of mainland breaking and affidavit were contemporaneous. The more youthfull grouping appears to have been influenced by minor reactivation of a more seasoned blame.

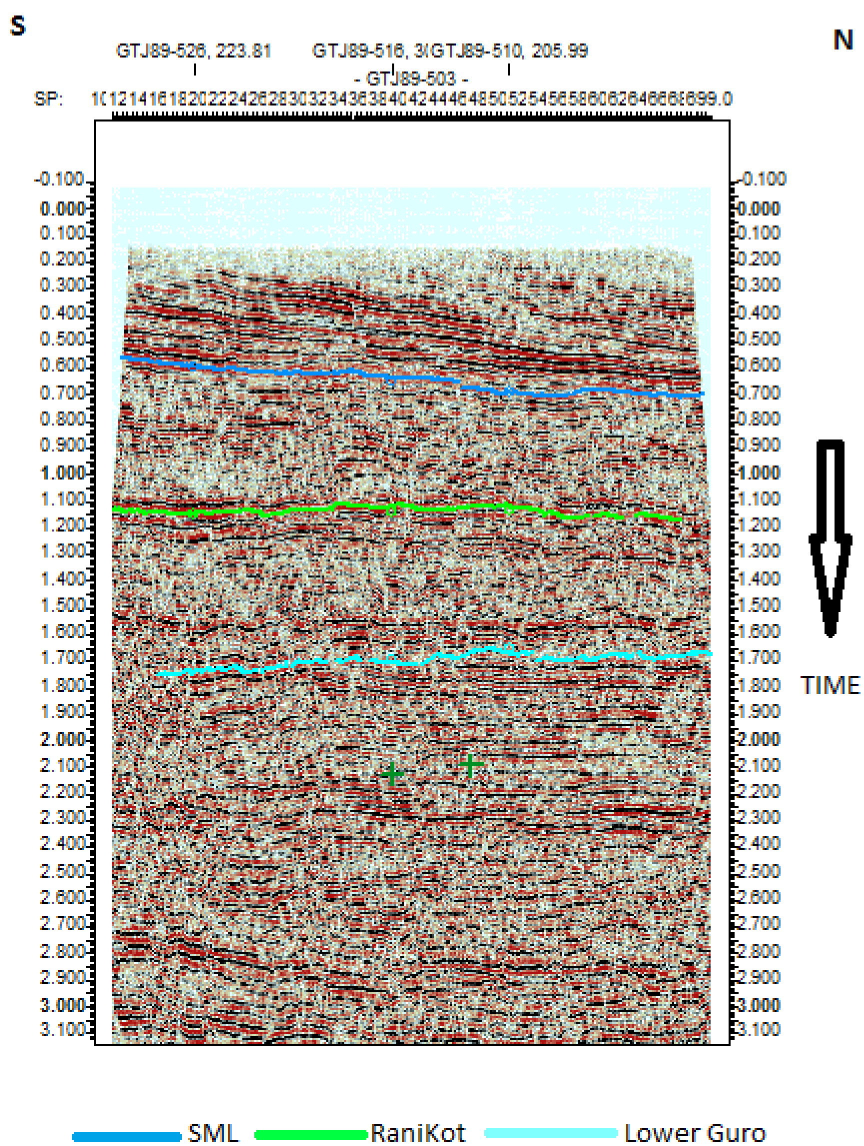


Fig.4.4: Interpreted Seismic section of GTJ89-503.

4.4.1: Seismic line GTJ89-510

Figure 4.5 shows NE-SW dip oriented seismic line GTJ89- 510, showing marked horizons Sui Main Limestone, Lower Goru and Ranikot.

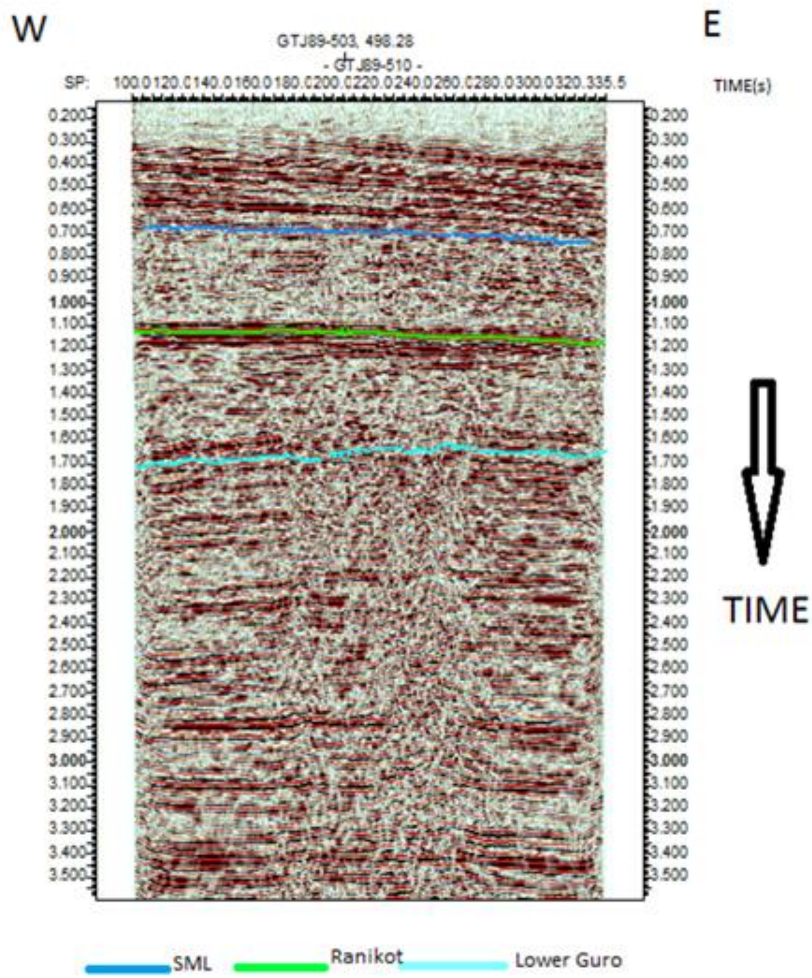


Fig.4.5: Interpreted Seismic section of GTJ89-510

4.4.2: Seismic line GTJ89-512

Figure 4.6 shows NE-SW dip oriented seismic line GTJ89- 512, showing marked horizons Lower Goru and Ranikot.

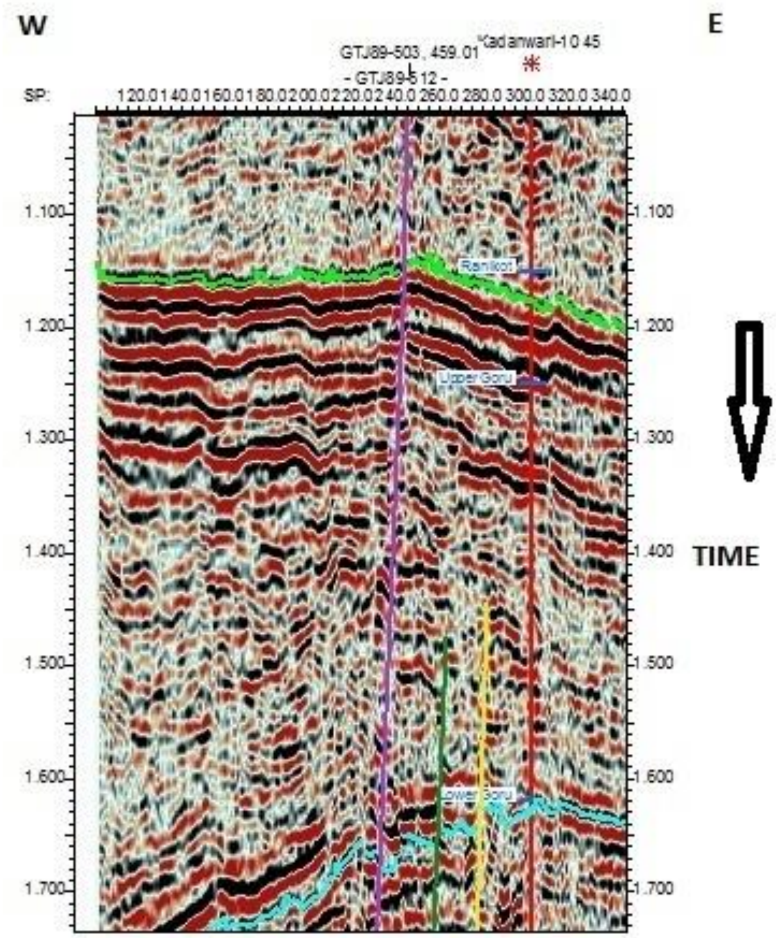


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Fig.4.6: Interpreted Seismic section of GTJ89-512 Time(s)

Above mentioned figures are showing marked horizons of SuiMain Limestone, Lower Goru and Ranikot terminated by normal faults. Faults are represented on the seismic sections (fig. 4.6) as a discontinuous reflection along marked horizons. The subsurface structures are related to normal faults in East and West. The pattern of seismic reflections from the strata within the basin suggests that the processes of continental rifting and deposition were contemporaneous. The younger sequence seems to have been affected by minor reactivation of an older fault.

4.3 CONTOUR MAPS

The last results of all the seismic investigation are the form maps, time or depth. Mapping is a piece of the understanding of the information, the one on which the whole operation depends for its value. The shapes are the lines of equivalent time or depth meandering around the guide as directed by the information **(Coffeen, 1986).**

Molding speaks to the three-dimensional structure on a two dimensional surface. These shape maps uncover the incline of the arrangement, basic alleviation of the development, its plunge and any blaming and collapsing. The deciphered seismic information is formed for delivering seismic maps which give a three-dimensional photo of the different layers inside a territory which is encircled by meeting shooting lines. These time and depth shape maps have been produced with the assistance of Seismic Micro Technology SMT (Kingdom 8.6).

4.4 Time Contour Maps of Marked Horizons

Time shape maps at the level of stamped horizons i.e. Lower Goru is appeared In **Fig**4.7 time shape map of lower Goru with form interim of 0.5 second is appeared, In the NE Lower Goru horizon is shallow and the depth of horizon increments towards west. Shut forms indicates basic trap

In **Fig 4.7,** Time contour map of Lower Goru Formation contour interval is 0.005 Four lines are interpreted three lines are adjacent GTJ89-508,GTJ-510 GTJ89-512 and one strike line GTJ89-503.

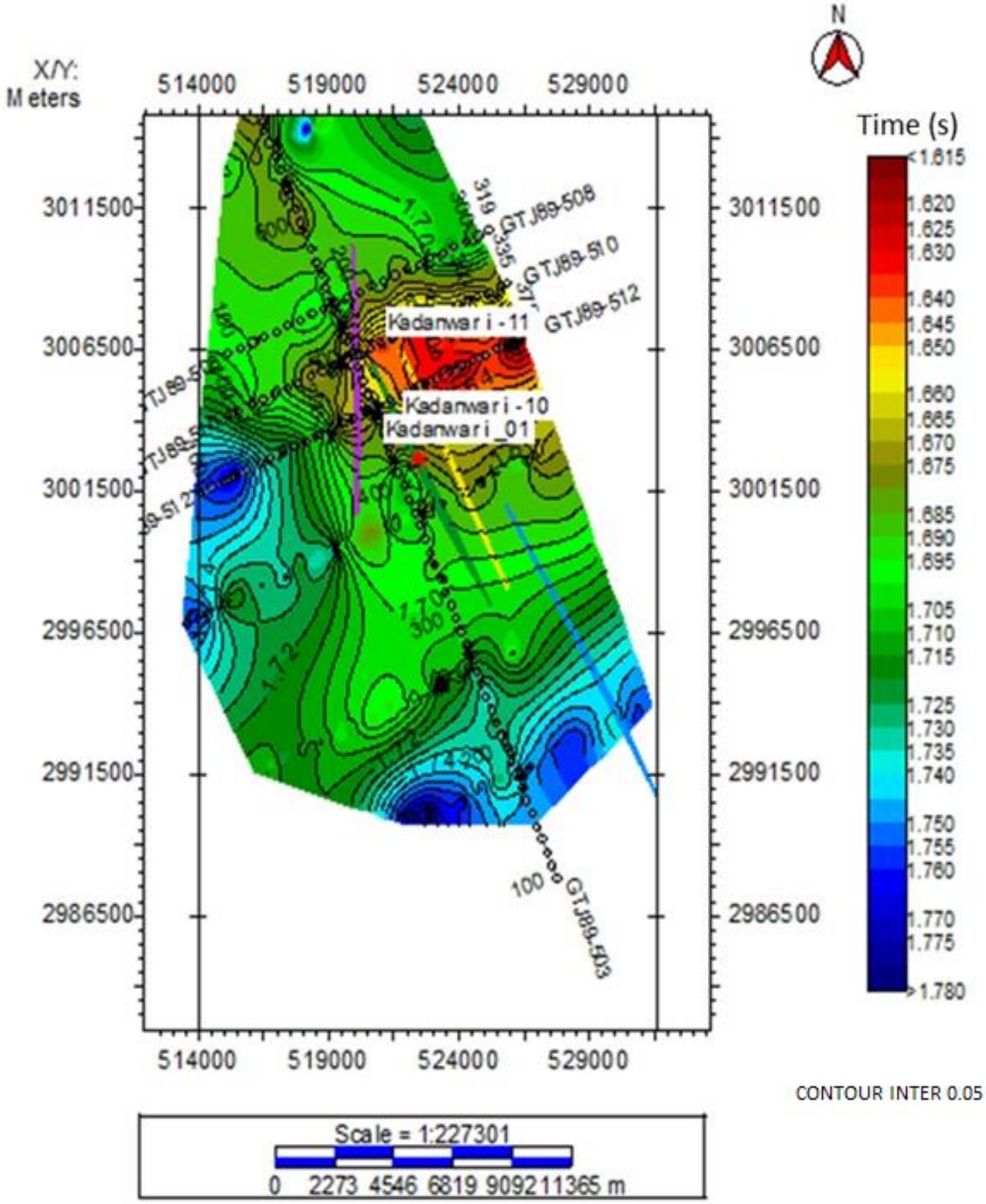


Fig 4.7 Time contour map of Lower Goru Formation

Time contour map of Ranikot Formation see in Fig (4.8) contour interval is 0.005 Four lines are interpreted three lines are adjacent GTJ89-508,GTJ-510 GTJ89-512 and one strike line GTJ89-503.

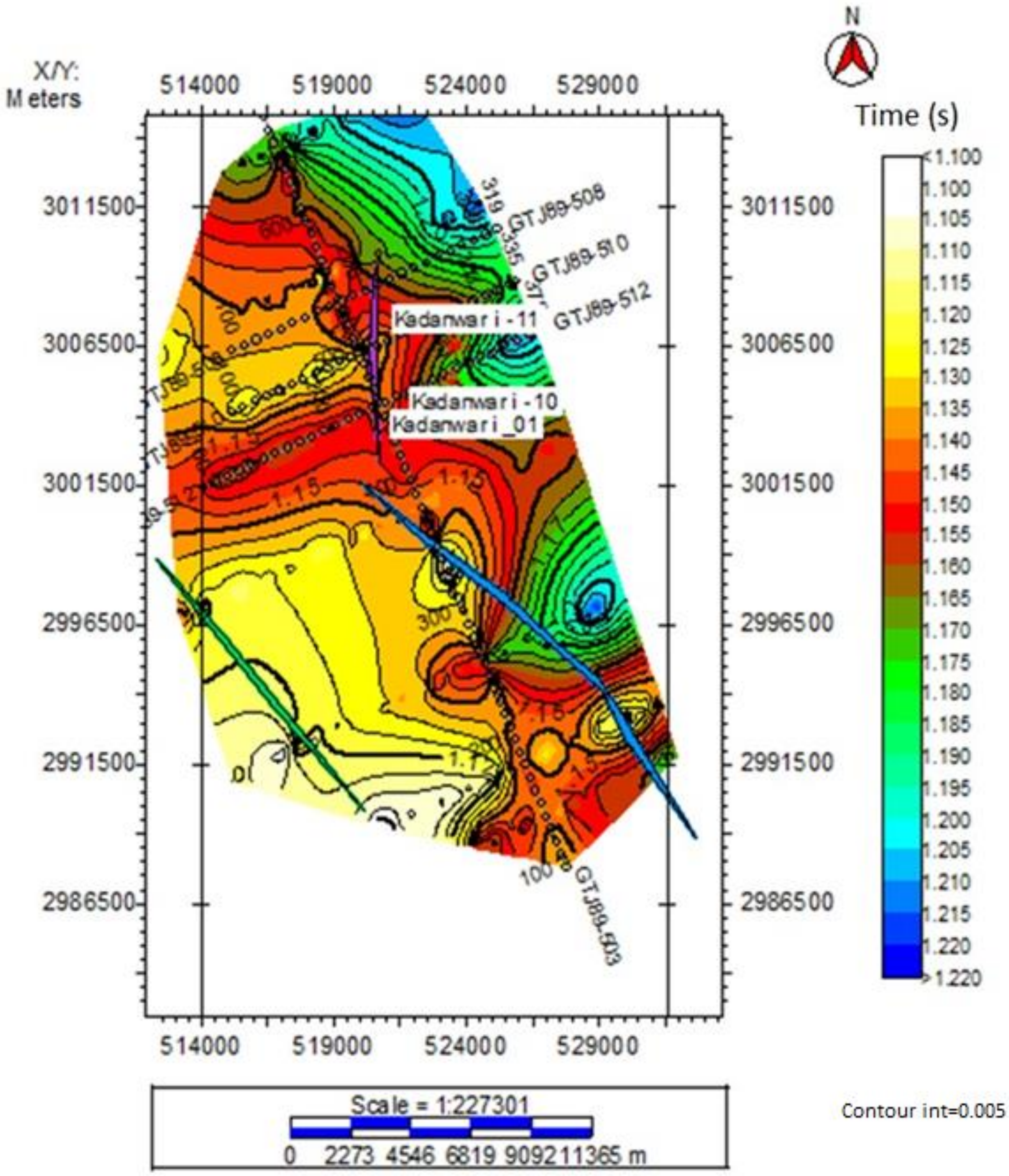


Fig4.8 Time contour map of Ranikot Formation

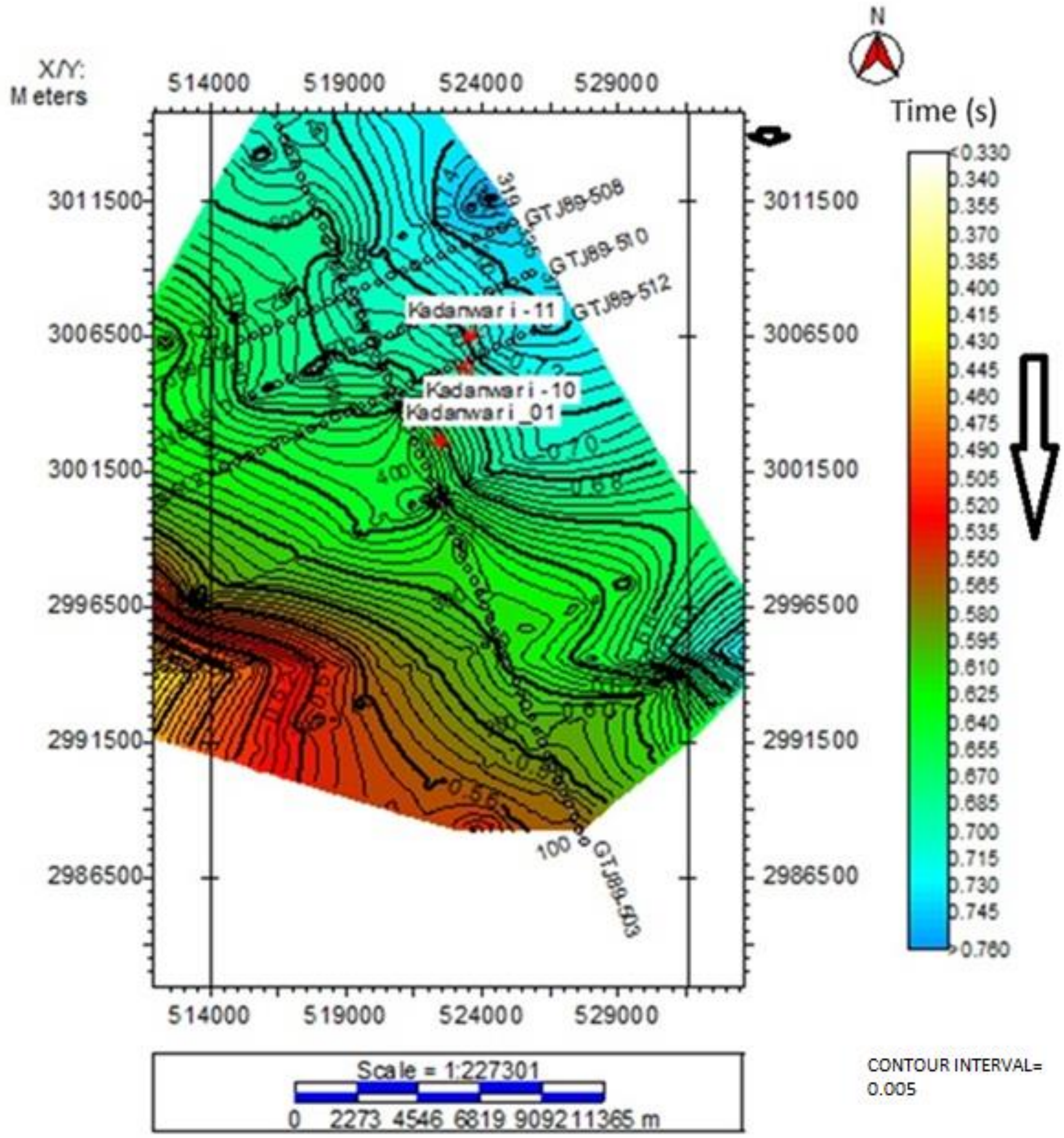


Fig4.9 Time contour map of Suimain Formation

In Fig 4.9 shows Time contour map of Suiman Formation with contour interval .005

The velocity used for time to depth conversion is average velocity as we know :-

$$S = v\,t/2$$

According to above relation we need avg velocity for time to depth conversion.

4.4.2 Depth Contour Map

The depth contour maps demonstrate the horizon depth variety, the depth form base map of the Lower Goru appeared in Fig. 4.10 and Fig.4.11 having form interim of 10m infers that the depth of the Lower Goru horizon is shallow in eastern part and towards the western district the depth increments. The region of shut forms in NE indicates structural trap and likely area for hydrocarbon amassing.

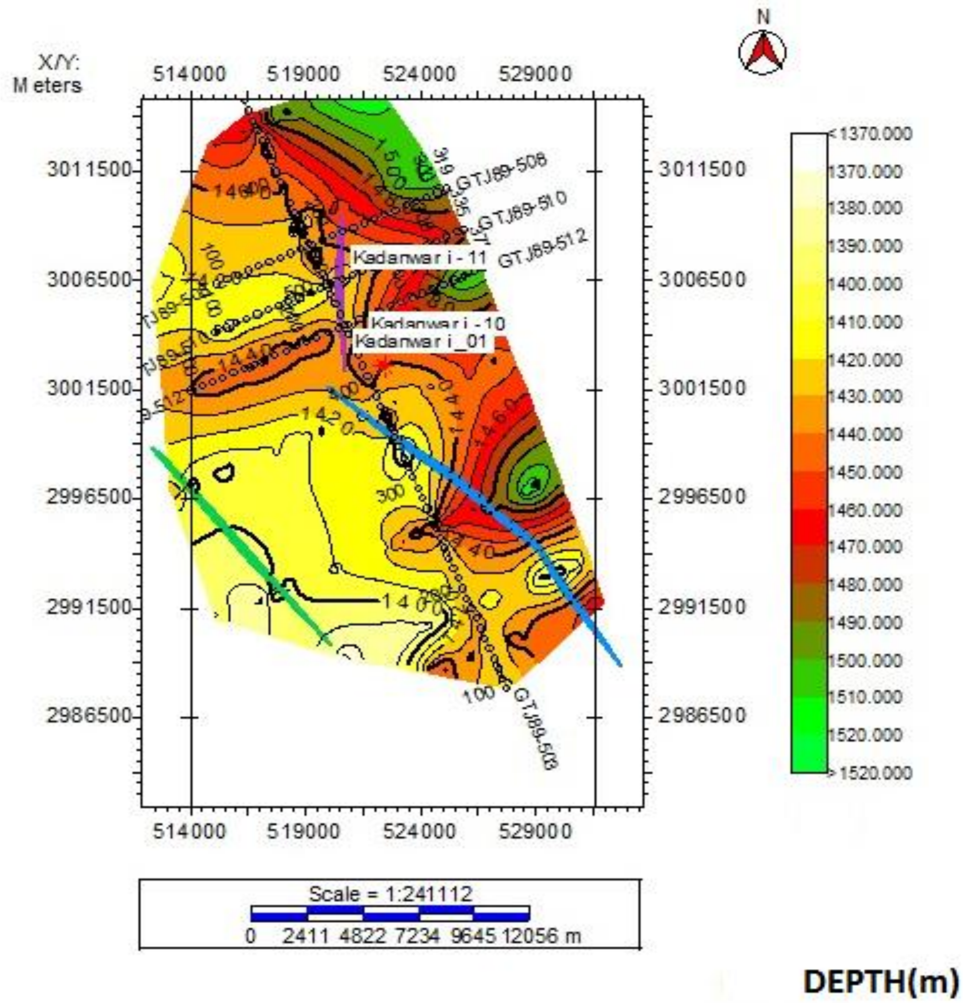


Fig. 4.10: Depth contour map of Ranikot Formation

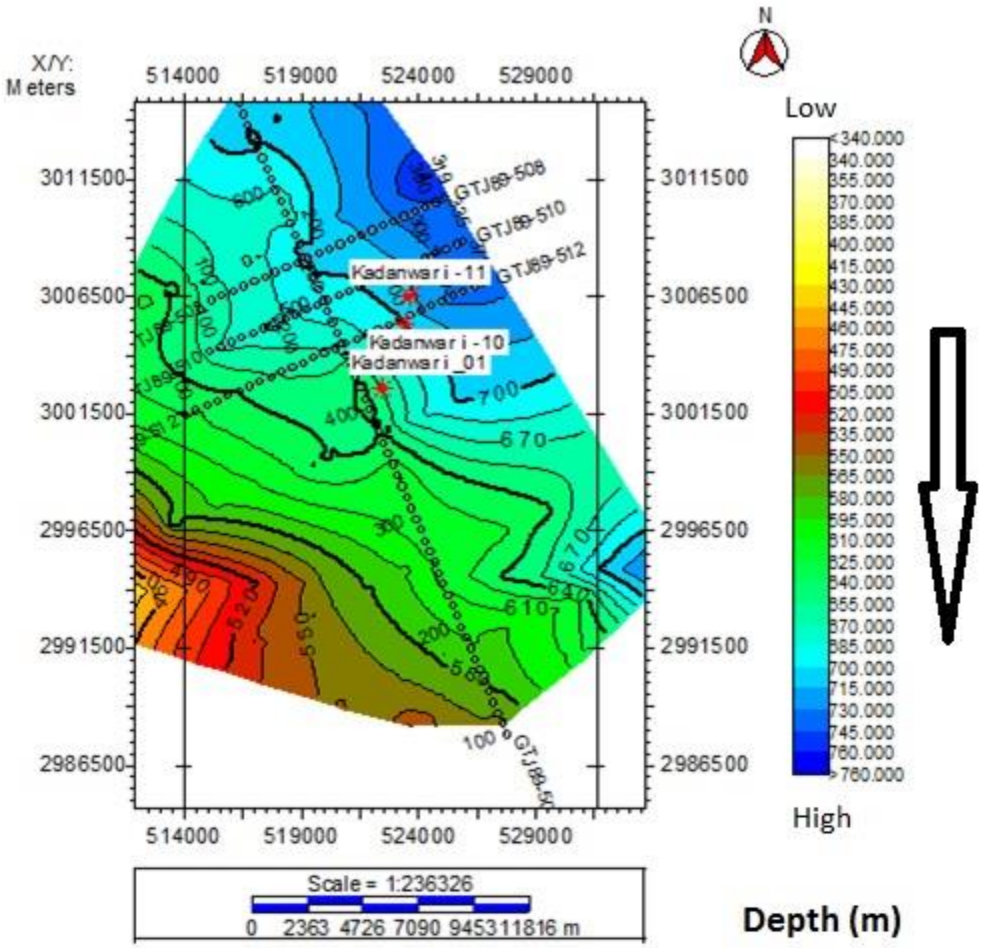


Fig. 4.11: Depth contour map of Suiman Formation

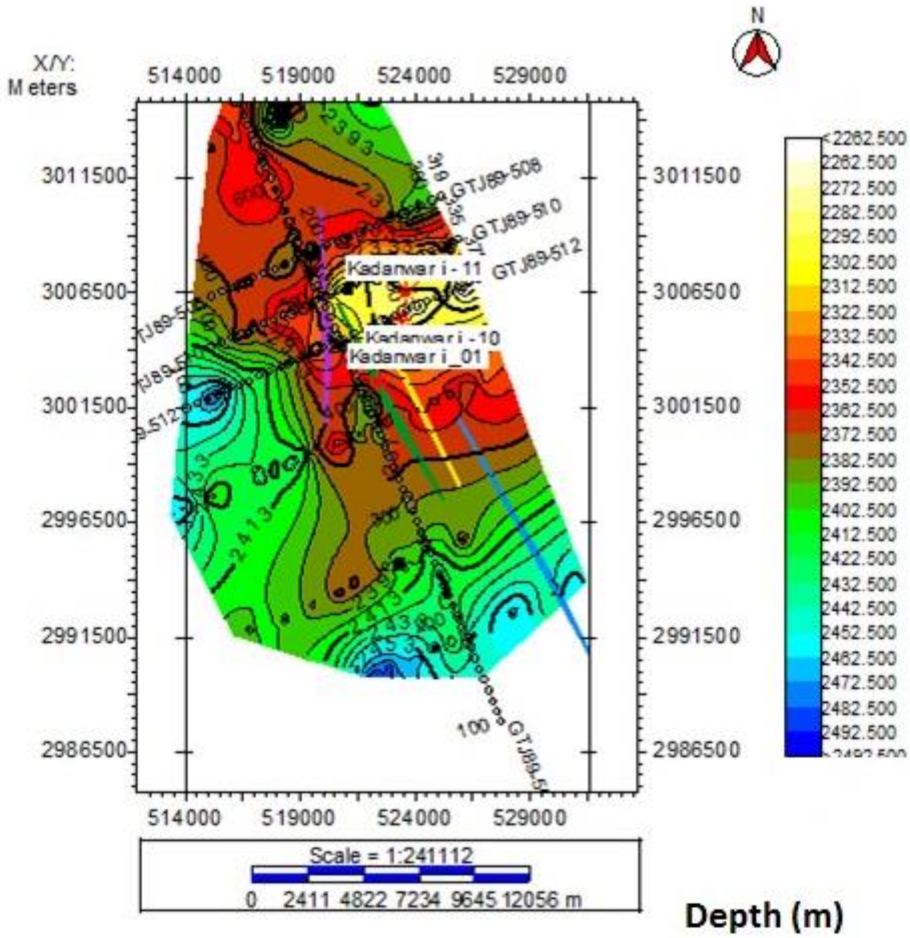


Fig 4.12 depth contour map of Lower Goru Formation

Fig. 4.12 demonstrates the depth contour map of Lower Goru having form interim of 10m. It can be deciphered effortlessly that in the eastern area the depth of the Lower Goru development is shallow and the depth of horizon increments towards SW heading.

CHAPTER 5 SEISMIC ATTRIBUTES

5.1 SEISMIC ATTRIBUTES

A seismic attributes is any amount derived from seismic data utilizing measured time, amplitude, frequency ,attenuation lessening or any mix of these. It expects to yield a subset of the information that evaluates shake and liquid properties as well as permits the acknowledgment of geologic examples and elements. All seismic characteristics are post-stack yet there are few pre-stack ones. They can be measured along a solitary seismic follow or all through different seismic follow. The principal ascribes created were identified with the 1D complex seismic follow and included envelope abundance, immediate stage, prompt recurrence, and clear extremity. Acoustic impedance acquired from seismic reversal can likewise be viewed as a property and was among the principal created. In this exploration quality investigation for real store in the region i.e. Lower Goru Formation has been ascertained.

5.2 CLASSIFICATION OF SEISMIC ATTRIBUTES

The Seismic Attributes are ordered fundamentally into two classes.

i. **Physical Attributes.**

ii. **Geometric properties.**

5.2.1 PHYSICAL ATTRIBUTES

Physical properties are characterized as those traits which are straightforwardly identified with the wave proliferation, lithology and different parameters. These physical properties can be additionally delegated pre-stack and post-stack qualities. Each of these has sub-classes as momentary and wavelet traits. Momentary characteristics are figured example by test and show constant change of qualities along the time and space pivot. The Wavelet qualities, then again speak to attributes of wavelet and their sufficiency range. Post stack traits are gotten from the stacked information.

5.2.2 GEOMETRICAL ATTRIBUTES

The Geometrical qualities are plunge, azimuth and irregularity. The Dip quality or plentifulness of the information relates to the plunge of the seismic occasions. Plunge is valuable in that it makes blames more noticeable. The sufficiency of the information on the Azimuth ascribe compares to the azimuth of the most extreme plunge heading of the seismic component.

5.3 ATTRIBUTES ANALYSIS

Following credits were connected to line TJ89-512 and the outcomes are translated.

5.3.1 Dip Variance

Plunge difference credit is intended to check irregularity in seismic information. So it is put in the classification of irregularity qualities. Fundamentally it utilizes measurable change (squared contrasts) of "neighboring" seismic amplitudes. The accompanying are the upsides of irregularity properties **(Brouwer and Huck, 2011).**

i. **Automated blame outline .**

ii. **Assistance in manual blame picking.**

iii. **Auto following of seismic skylines in time cuts without blame picks**

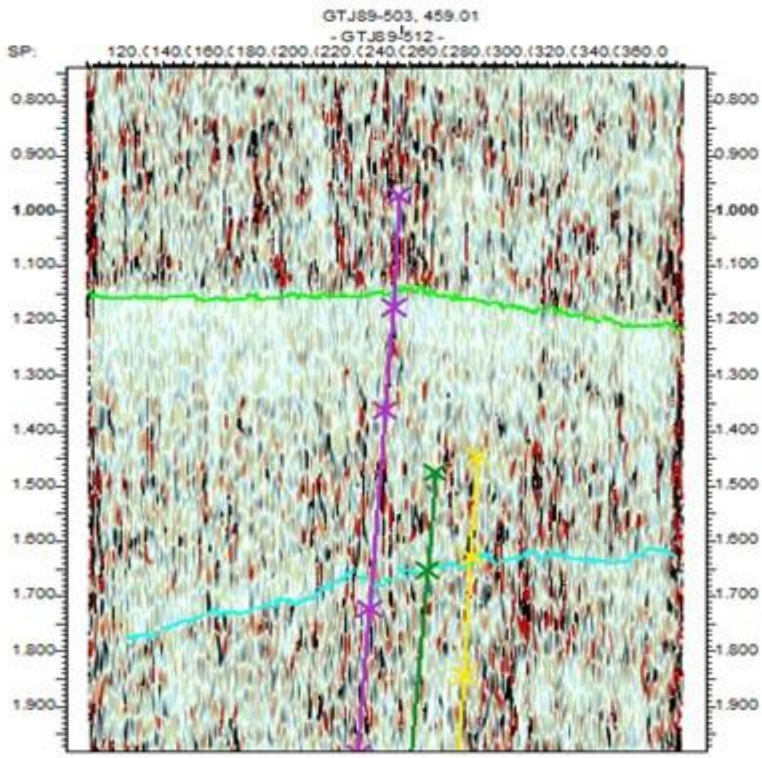


Fig. 5.1 Dip variance attributes applied to TJ89-512.

In line TJ89-512 plunge difference trait is connected and appeared in Figure 5.1, white part obviously depict the flaws and their heading and demonstrates that shortcomings and skylines are picked effectively.

5.3.2 Instantaneous Frequency

Immediate Frequency (Hz) is the rate of progress of stage after some time (Sheriff, 1999).

$$Freq(x,t)=\frac{\partial \arctan[g(x,t)*f(x,t)]}{\partial(t)}=\frac{\left[f(x,t).\frac{dg}{dt}-g(x,t).\frac{df}{dt}\right]}{\left[f^2(x,t)+g^2(x,t)\right]}$$

Since the stage work is multi-esteemed with bounced, the momentary recurrence is really registered as the subordinate of the arctangent work, which stays away from the discontinuities. Quick frequencies relate the wave engendering and depositional condition, thus they are physical qualities and they can be utilized as compelling discriminators, (Subhramanyam, D. what's more, **Rao, P.H. 2008)**

i. Instantaneous recurrence can show bed thickness and furthermore lithology parameters.

ii. Indicates the edges of low impedance thin beds.

iii. Hydrocarbon pointer by low recurrence irregularity. This impact is once in a while complemented by the unconsolidated sands because of the oil substance of the pores.

iv. Fracture zone pointer, show up as lower recurrence zones.

v. Bed thickness marker.

vi. Higher frequencies demonstrate sharp interfaces or thin shale bedding, bring down frequencies show sand rich sheet material.

High Instantaneous recurrence demonstrates a total progression in whole repository with breakage sooner or later, indicating low recurrence, affirms the faults which unmistakably demonstrate that reflectors and issues has been stamped are accurately In Figure 5.2

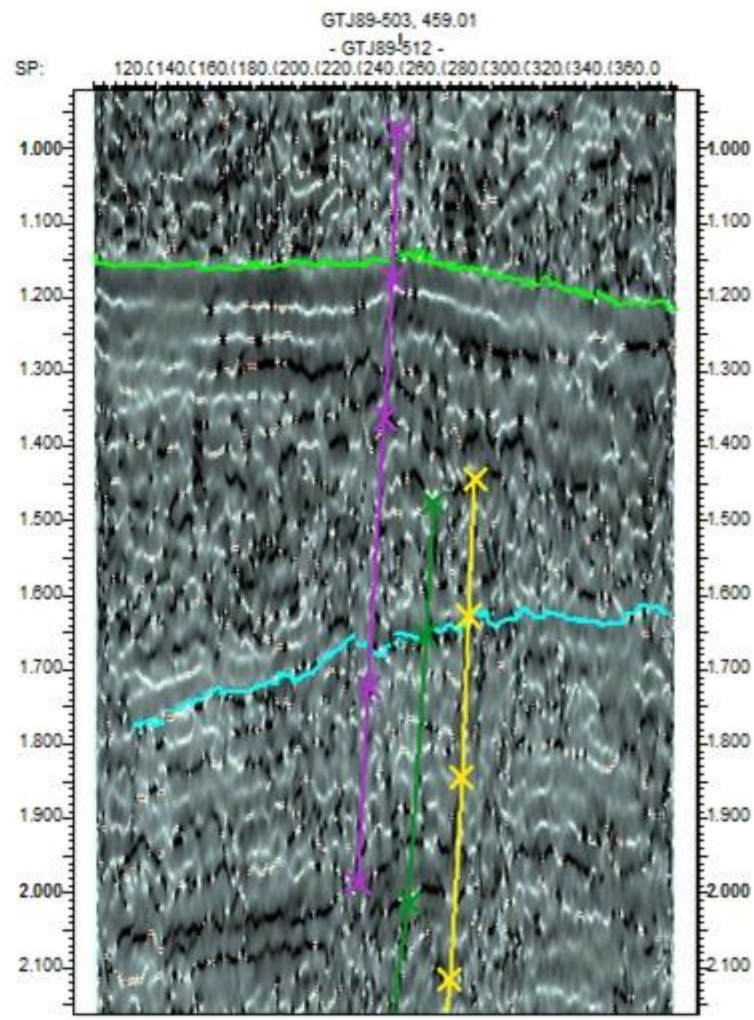


Fig. 5.2 Instantaneous frequency attribute applied on TJ89-512

5.3.3 Envelope of Trace

The Hilbert Transform of the seismic follow produces a nonexistent follow and utilizing both these follows the envelope follow is processed. The envelope of seismic follow has a low recurrence appearance and have just positive amplitudes. It can highlight primary seismic elements on the area. Really this envelope speaks to the immediate vitality of the flag and is relative in its size to the reflection coefficient (Subrahmanyam &Rao, 2008).

This quality speak to for the most part the acoustic impedance differentiate, subsequently reflectivity. It generally stays positive whether the reflection coefficient is certain or negative. Figure 5.3 unmistakably indicates reflection qualities of checked seal and store skyline on GTJ89-520.

This characteristic is mostly valuable in distinguishing;

i. Bright spots

ii. Gas aggregation

iii. Sequence limits, real changes or depositional situations

iv. Major changes of lithology.

v. Local even changes demonstrating blaming.

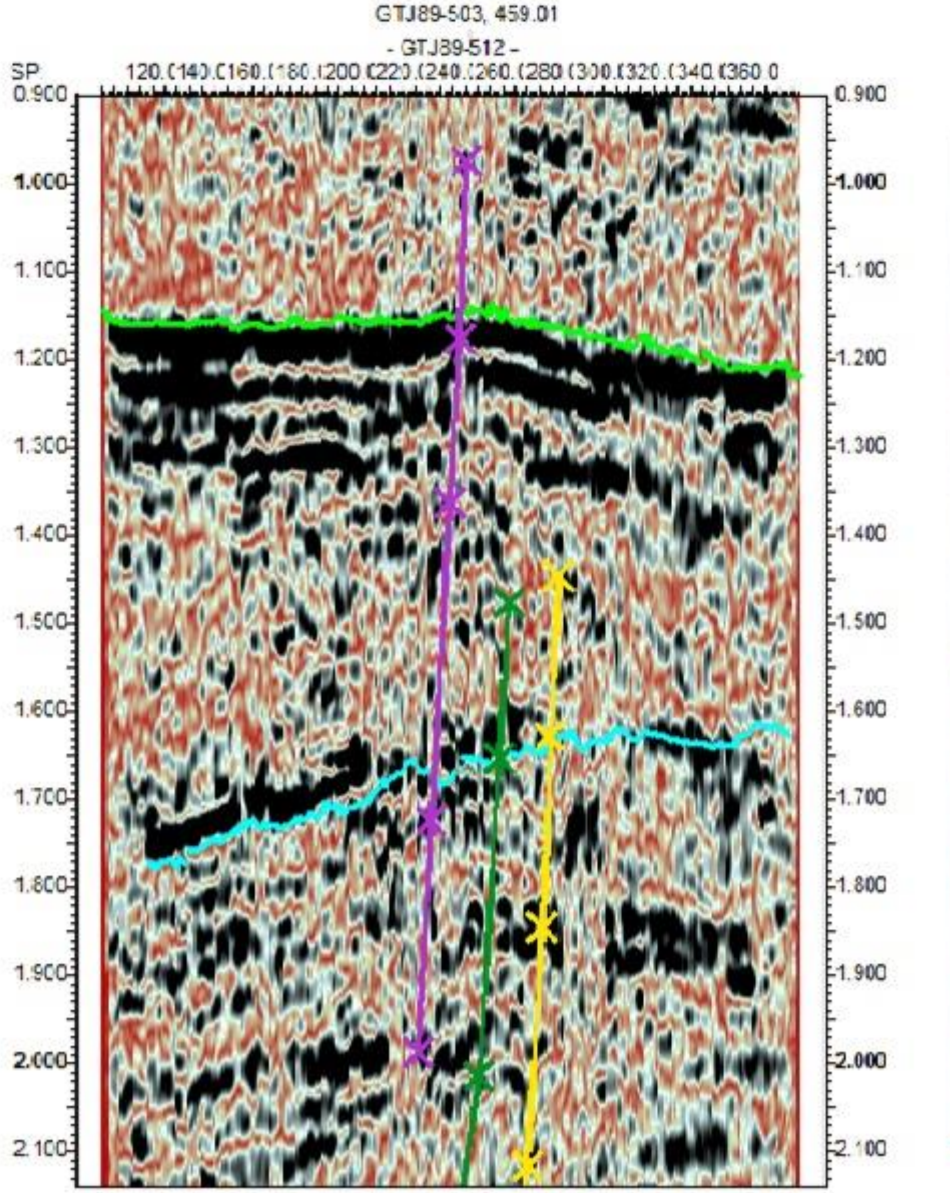


Fig. 5.3 Trace Envelop attribute applied on TJ89-512.

CHAPTER 6 ROCK-PHYSICS AND PETROPHYSICAL ANALYSIS

6.1 INTRODUCTION

Rock Physics describes a reservoir by physical properties such as porosity, rigidity, compressibility properties that will affect how seismic waves physically travel through the rocks, and to establish a relation between these materials and the observed seismic response of a rock at certain physical conditions. The techniques can be used for rock physics modeling, i.e. to predict the elastic (seismic) properties from the geology, or for rock physics inversion, and to predict geology from elastic (seismic) observations.

Quantitative Seismic Interpretation shows how rock physics can be functional to predict different parameters of reservoir, such as pore fluids and lithologies, from seismically resulting attributes. It demonstrates how the multidisciplinary combination of rock physics models with seismic data, sediment-logical information and stochastic techniques can lead to more powerful results than can be obtained from a single technique. This provides an integrated methodology and practical tools for quantitative interpretation, characterization of reservoirs in the subsurface and assessment of uncertainty, using seismic and well-log data. The aim, in preparing Quantitative Seismic Interpretation, is to aid illustrate the potent role that rock physics can play in integrating both the data and expertise of geology and geophysics for characterization of reservoir. The Quantitative Seismic Interpretation includes the use of any seismic attribute for which there are specific models and relates them to different rock properties. This technique introduces primary rock physics relations, which help to quantify the fluid properties and geophysical signatures of rock. Since rock properties are outcome of geologic processes, I begin to quantify the seismic signatures of various geologic trends.

Instead of using a regional averaged velocity function which only shows a vertical mean trend of the velocity with depth velocity of DT log was used. The RMS and average velocities are not the true representative of a particular subsurface layer as they provide a vertically summed effect of all overlying layers rock properties.

6.2 ROCK PHYSICS ANALYSIS OF LOWER GORU FORMATION

By using wire line log data of GORWAR-01, rock physics properties of Lower Goru formation were calculated. These properties were calculated from 1600m to 3600m depth. The rock Physics properties of Lower Goru are given below:

6.2.1-Wave Velocity and S-wave Velocity:

Sonic travel time of compressional wave is generally used as porosity tool for given lithology. VP-VS relations are keys to the determination of lithology from Seismic and Sonic log data as well as for direct seismic identification of pore fluids using e.g. AVO analysis with passage of time as the waves go deeper, its values are decreasing. Introducing shear wave travel time is very helpful in determining mechanical rock properties. It is found that compressional wave is sensitive to the saturating fluid type.

Fig. 6.1 shows the plot between P wave and S wave velocity vs. depth for the reservoir of the locale i.e. Lower Goru.

Lower values of P-wave and S-wave velocities show the shaly material or fluid substitution and higher values consolidated material. Seismic velocity increases with depth due to compaction of rocks, because of overburden pressure of rocks. S-wave velocity is best indicator of fluids, as these waves can’t pass through fluids.

Mathematical formula for the calculation of S-wave is given below:-

$$\mathrm{Vs} = (\mathrm{Vp} - 1.36)/1.16$$ (Castagna et al., 1995)

6.2.2 Bulk Modulus:

The bulk modulus (K) of a substance measures the substance's resistance to uniform compression. It is the ratio of volume stress to volume strain. It is defined as the pressure increase needed to affect a given relative decrease in volume. It describes the material's response to uniform pressure. For a fluid, only the bulk modulus is meaningful. When pressure is applied to a specimen its volume decreases but shape and mass remain unchanged, however the density of the specimen **increases (Robinson, E.S, and Coruch, C.,1988).**

Fig. 6.1 shows the graph plot for reservoir rock between depth and Bulk Modulus. Lower values show the shaly material or fluid substitution and higher values implies consolidated material.

$K = -\Delta P/ (\Delta V/V)$

6.2.3 Young’s Modulus

Young's modulus (E) is a measure of the stiffness of an isotropic elastic material. It is defined as the ratio of the uniaxial stress over the uniaxial strain in the range of stress in which Hooke's Law holds. It describes the material's response to linear strain.

$$E=(FL_o)/(A_O*del.\ L)$$

where

E is the Young's modulus (modulus of elasticity)

F is the force exerted on an object under tension;

A_0 is the actual cross-sectional area through which the force is applied;

ΔL is the amount by which the length of the object changes;

L_0 is the original length of the object.

Fig. 6.1 shows the graph plot between Young's Modulus and depth for Lower Goru. From the graph pot it can be concluded that the lower values show the shaly material or fluid substitution and higher values consolidated material.

6.2.4 Shear Modulus

Shear modulus or modulus of rigidity (μ,S), is defined as the ratio of shear stress to the shear strain (angle of deformation).

$$\mu = \rho * Vs$$

Where μ = Shear modulus

ρ= Density

Vs= S-wave velocity

Fig. 6.1 shows the graph plot between Shear Modulus and depth for Lower Goru. Lower values show the shaly material and higher values stiffer material. Shear Modulus is good indicator of fluid presence, because fluids have zero value of Shear Modulus.

6.2.5 Poisson's Ratio:

Poisson's ratio (σ) is the ratio of transverse strain (normal to the applied load) to longitudinal strain (in the direction of the applied load). When a sample of material is stretched in one direction, it tends to contract (or rarely, expand) in the other two directions. Conversely, when a sample of material is compressed in one direction, it tends to expand (or rarely, contract) in the other two directions.

$$\sigma = \frac{0.5(Vp^2 - 2Vs^2)}{Vp^2 - Vs^2}$$

The graph between depth and Poisson's ratio is shown in Fig. 6.1. Higher values of Poisson's ratio indicate the presence of fluid or non-consolidated material, where as the lower values of the parameter shows the presence of the consolidated material or stiffer lithology.

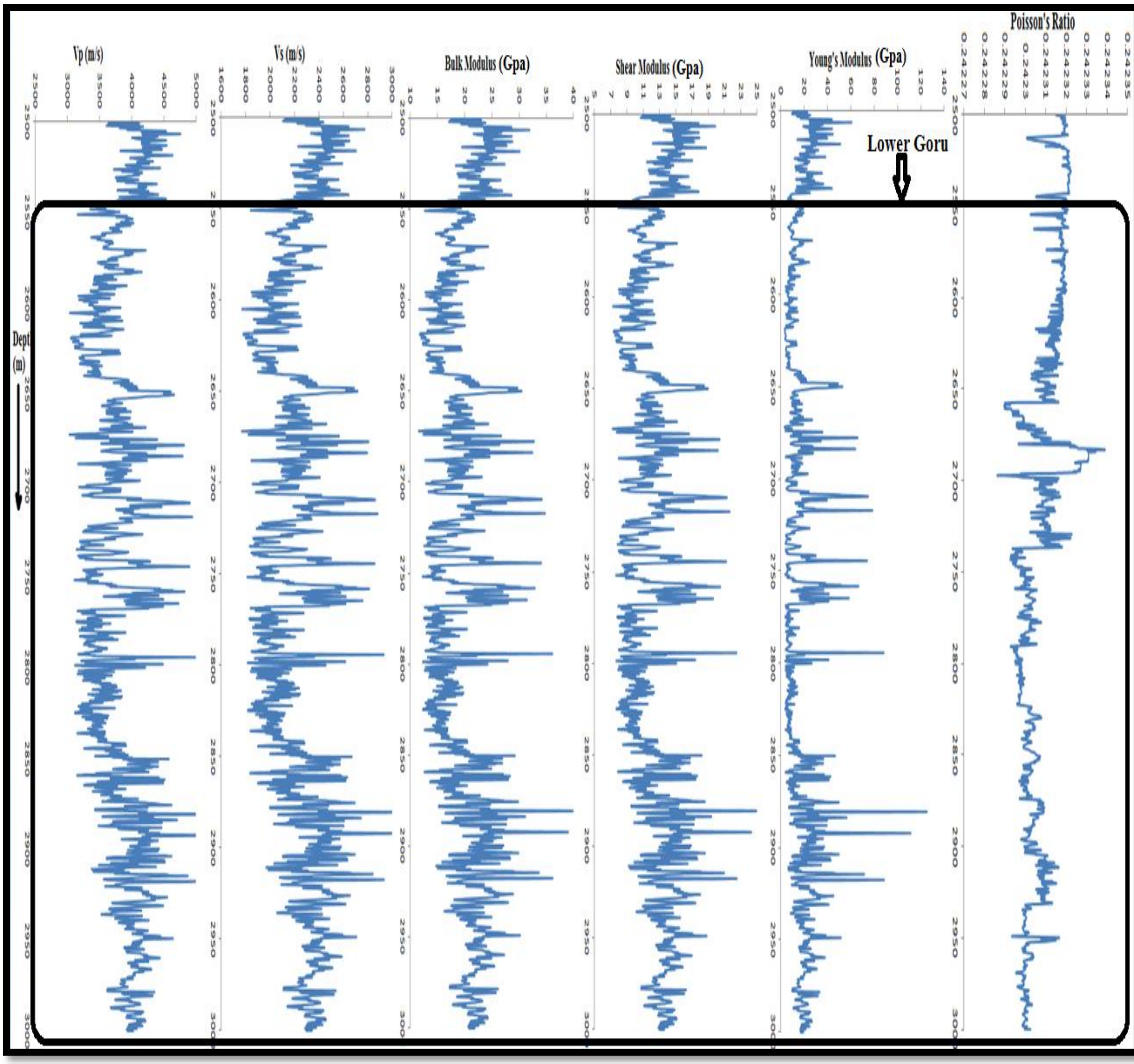


Fig 6.1 Depth relation vs Vp/Vs Bulk modulus ,shear modulus,young modulus and poisson ratio

The behaviour of bulk and shear modulus against reservoir is that they show decrease trend where we have a hydrocarbon .

6.3 Petrophysical Analysis of Kadanwari-01 Well:

In the project we have been provide with three wells but we selected the Kadanwari-01 due to its complete data. Secondly that was the key well that was used for well to seismic tie.

In the Petrophysical analysis we have used Archie's Interpretation to calculate the following.

- Effective Porosity.
- Volume of Shale.
- True Resistivity.
- Water Saturation.
- Bulk Volume of Rock
- Hydro-Carbon Saturation.

The values are then put into template and we have got hydrocarbon shows in the Lower Formation.

- CRITERIA ADOPTED FOR MARKING ZONE:
- Criteria adopted for marking zone of interest IN petrophysics is:-
- Low GR, which mean clean lithology which is my case is sand.
- Calliper is stable.
- Separation between LLD and LLS.
- RHOB,NHPI cross over.
- Relatively higher effective porosity.
- Low water saturation.
- High hydrocarbon saturation.

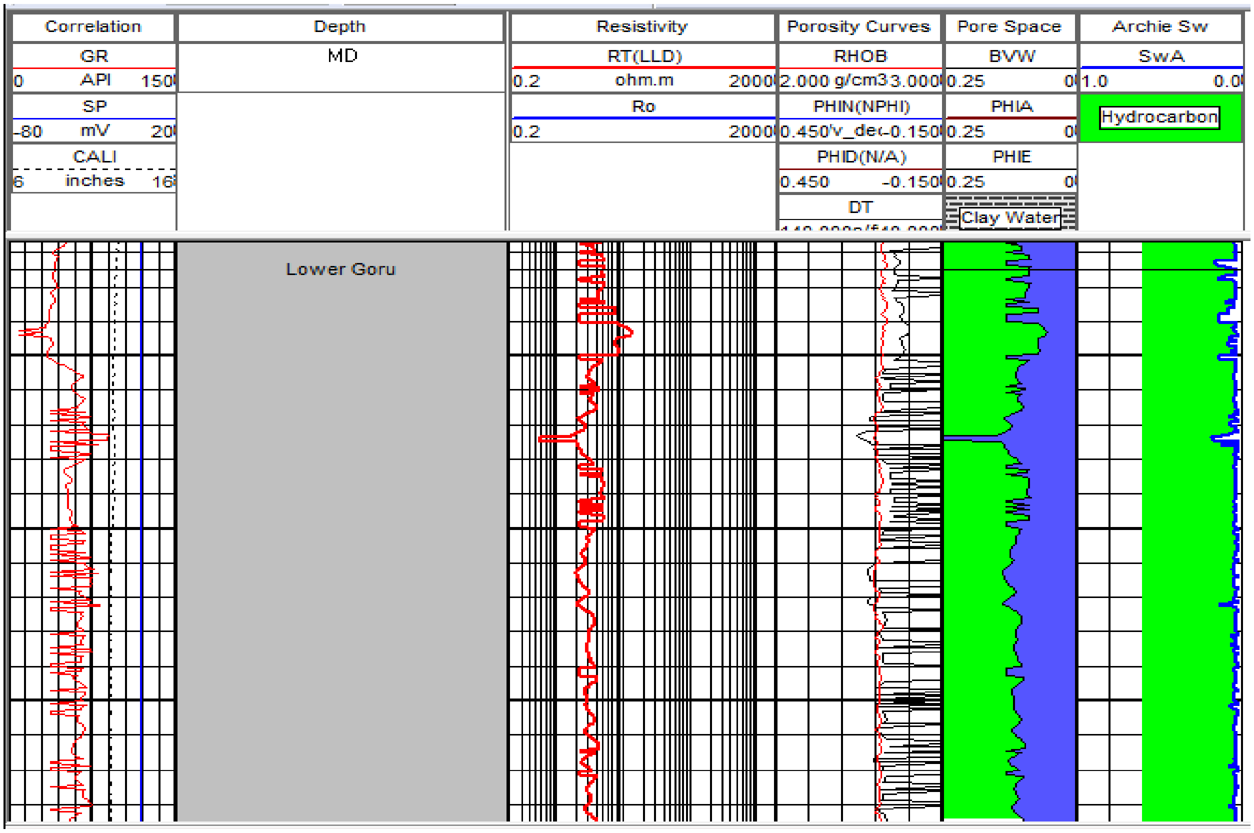


Fig 6.2 PETROPHYSICS ANALYSIS KADANWARI WELL 01

6.4 Regional Cross-section of Wells:

We have been provided with the three wells i.e. Kadanwari-01, 10 and Kadanwari-11. Formations data has been gathered for these wells and using those formation the cross-section of all the three wells has been constructed. This cross-section is drawn from Kadanwari-01 to 11. It shows the thickness of formation tops in between wells and also shows the trend and dip of each formation.

We use different techniques to achieve our goals. The most basis techniques are**:**

Petropysics

The term rock physics contains the range of techniques that relate the geological properties(I.e porosity, lithology, saturation) of a rock at certain physical conditions (e.g pressure, temperature) with the corresponding elastic and seismic properties (e.g elastic modulus, velocity, impedance).

Importance of rockphysics:

It is the brigdge to determine accurate relations between rock properties and seismic attributes can to put "flesh on the bones" of a seismic interpretation. That is, rock physics allows the interpretater to put "rock properties together with seismic horizons". (peeters). Typical rock physics studies will answer questions such as:

Can porosity and saturation be obtained from (seismic) interval velocity?

What are the velocity-porosity relations in various lithologies?

Is seismic avo response sensitive to gas saturation to gas saturation levels in a particular play?

PETROPHYRICS:

Petrophysics is the study of physical and chemical properties which defines the occurrence and behavior of rocks and the containing hydrocarbons (oil and gas). Petrophysical interpretation is the process which leads to combining the knowledge of tool response with geology, to provide a complete picture of the changes of important petrophysical properties with depth. **(ellis and singer, 2007).**

During petrophysical interpretation different logs were used.

Caliperlog , gamma ray (GR), neutron log (NPHI), density (RHOB), resistivity logs (LLS, LLD, and MSFL), core data and production data leads to petrophysical properties estimateion.each log has its own importance and contributes in quantifying the important reservoir parameter. Gamma ray is particularly use for for defining shale beds. When the sp is distorted or when the sp is featureless. The gamma ray log reflects the proportion of shale and in many regions and it can be used quantitatively as a shale indicator. It is also used for the detection and evaluation of radioactive minerals such as potash or uranium ore.

During the log analysis of wells , the gamma ray log is used for the interpretation of shale volume.**(rider, 2002)**

All the measurements and bore hole signatures have their own significance, but the traditional role of well logs has been limited to participation in evaluation of formation which is summerised as:

- ∇ Identification of reservoir and their nature (oil and gas)
- ∇ Delineation of pay zone in reservoir strata
- ∇ Quantification of hydrocarbon contained in the formation
- ∇ Estimation of recoverable hydrocarbons

Difference between the role of rock physics and petrophysics:

Rock physics

- Rock physics uses sonic, density, and dipole logs if available
- Rock physics aims to establish p-wave velocity (vp), s-wave(vs), density, and their relationships to elastic moduli (bulk modulus) and rigidity modulus, porosity, pore fluid, temperature , pressure etc, for the present lithologies
- It talks about velocities and elastic parameter, because , these are what link physics rock properties to seismic expression.
- Rock physics sometimes use information provided by the petrophysicist, such as shale volume, saturation levels, and porosity in establishing relations between rock properties or in performing fluid substitution analysis.
- Rock phyrics is the interest of geophysicist (and maybe physicists).

Petrophysics:

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

- Petrophysics can provide things like porosity, saturation , permeability, net pay , fluid contacts, shale volume, and reservoir zonation.
- Petrophysics is the interest of petroleum engineers , well log analysts, core analysts, geologist and geophysicts.

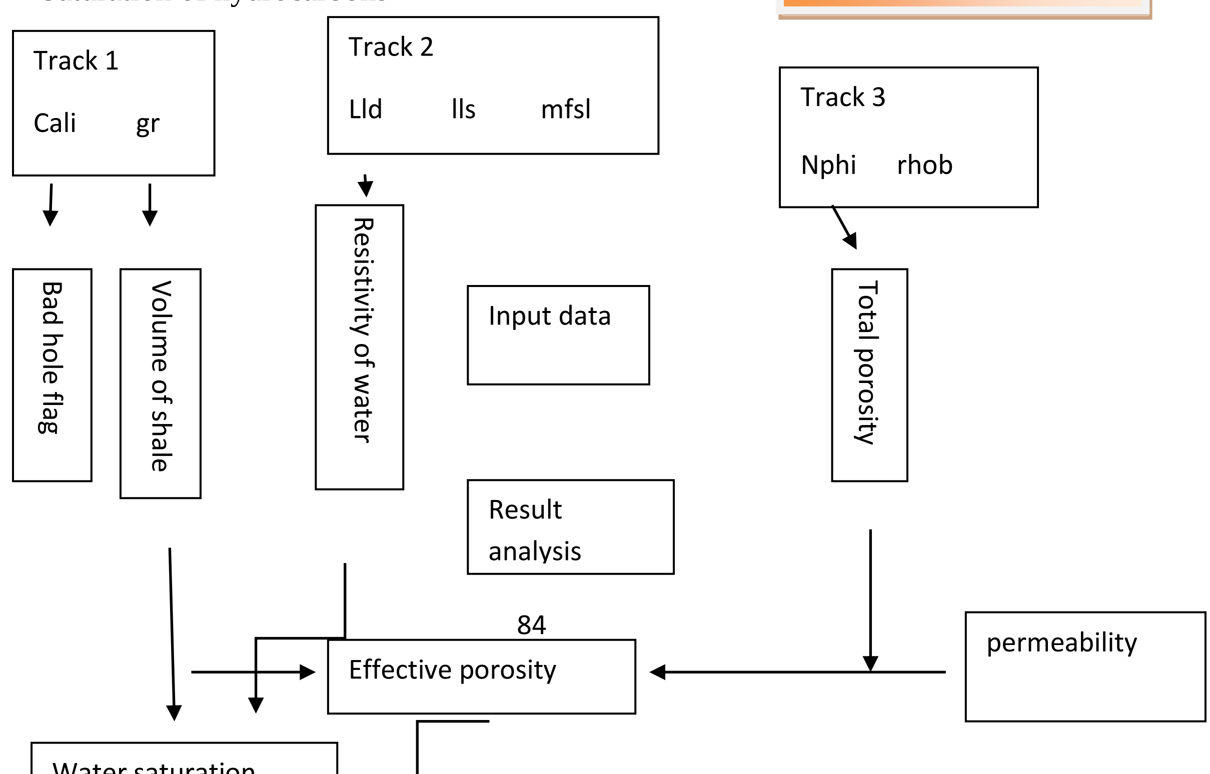
Data set:

The petrophysical analysis has been performed for reservoir characterization of kadanwari area. To achieve the goal data set of kadanwar 001 are used

Work flow for petrophysical analysis:

For petrophysics analysis a step by step work flow is followed to achieve the target for calculating petrophysical properties is described In fig. the log signature I,e caliper log, gamma ray (GR), neutron (NPHI), density (RHOB), letrollog deep (LLD), letrolog shallow (lLS) and micro- spherically focused log (MFSl).the steps are

- Marking the zone of interest
- Review input log curves
- Volume of shale calculation
- Calculation of formation water resistivty
- Saturation of hydrocarbons



Zone of interest:

The reservoir encountered in kadanwari wells was Lower Goru formations which was of lower cretaceous age. This Lower Goru formation was further divided into different zones. Acc.

Volume of shale (Vsh):

GR log is the most widely used for volume of shale determination. In the quantitative evaluation of shale content, it is assumed that radioactive minerals are absent in clean rocks as compare to shaly rocks. The volume of shale can be determined at any point with the following formula **(sclumberger, 1989).**

Vsh=GR log- Grmatrix/GR shale- GR matrix

GR log= Gamma ray log

Vsh= volume of shale

GR matrix= mininmum value of gamma ray

GR shale= maximum value of gamma ray

Effective porosity:

Effective porosity calculation is made from log signature of neutron, density, and volume of shale **(bhuyan and passy, 1994).**

Pore space contribute in effective porosity in producing such a pore spaces exclude capillary-bound water as well as isolated and clay bound water. Disaggregation of core sample gives total non-solid spaces from which the total porosity can estimated **(ellis and singer, 2007).**

It is the amount of inter.connected pore spaces. Effective porosity is calculated with the help of the following formula.

Phie= phix*(1-vsh)

Where ,

Phie= effective porosity

Phix= total porosity

Density porosity:

The porosity can be calculated at any point by using the netron, density and sonic logs. The porosity values as computed from various sources showed reasonable agreement with each other. Using the neutron, sonic and density logs, porosity values of interested zones are calculated . then total porosity and effecteive porosity can be calculated using the porosity values of densaity and newtron logs.

Density porosity:

The the following formula has been used to calculated the density porosity of the formation.

Phid= (rhom-rhob)/rhom-rhof)

Where,

Phid= density porosity

Rhom=density of matrix

Rhof=density of fluids

Rhob=values of density log at given point

Neutron porosity:

Neutron logs determine the hydrogen atom concentration in a formation. Hence the neutron log measures the fluid- fluid porosity. The values of newtorm porosity can be read directly from the neutron log curve (nphi).

Total porosity:

Total porosity or average porosity us calculated with the help of the following formula.

PHIX=(PHID+PHIN)/2

Where,

PHIX= Total Porosity

PHID=Density Porosity

PHIN = Neutron Porosity

CALCULAtion of water saturation:

During the log analysis of kadanwari wells the water saturation (sw) is calculated with the help of archie equation.

Sw)n= a/phi m * rw/rt

Where,

SW=water saturation

N= saturation exponent

A= lithological coefficient

PHI= cementation factor

RW= resistivity of water

Rt= true resistivity (deep resistivity) at that depth

The values of m, n, and a comes from the core analysis of the data. We assume these three values to be constant.

N=2 m=2 a=1

By putting values of these parameters and simplifying the above equation it becomes as follows. Archie equation is used because it gives the direct relationship between resistivity of water (rw) and true resistivity (rt) with water saturation. It is more realistic tha any other equations. Finally this water saturation is saturation is subtracted from 100% to give the hydrocarbon saturation.

Sw(%)= under root 1/PHI square * rw/rt *100

Hydrocarbon saturation:

The values of hydrocarbon saturation are calculated with the help of formula as under

Sh(%)= 100 –sw(%)

Where,

Sh(%)= hydrocarbon saturation percentage

Sw(%)= water saturation percentage

Permeable:

Permeable is the measurement of a rock strata ability to transmit fluids, typically measured in darcies or millidarcies. Permeability calculated using water saturation and effective porosity introduced by **(wyllie abd water, 1950)**. The relationship between permeable,effective porosity and irreducible water saturation which is later further developed by **(Timur, 1968).**

Perm= kw* PHID/Swe

Where,

D=4.4

E=2

Kw= 3400 for oil

Kw= 340 for gas, according to timur modification

Petrophysical interpretation:

The petrophysical results are shown graphically for further interpretation. The crossover on the density-Neutron log sometimes may be the indicator of presence of gas. Resistivity logs are very helpful to identify the hydrocarbon in reservoir rocks. Higher resistivity values usually caused by shale.

Unmoved hydrocarbons:

It is the difference between bulk volume moved water and the effective porosity . it represents the portion of pore space adjacent to the borehole in which hydrocarbons remain.

Moved hydrocarbon:

It is the difference between bulk volume water and bulk volume moved water. It represents the zone adjacent to the borehole that is invaded by mud fluid.

CONCLUSION

From our interpretation it is concluded that there is a complex structural deformation in the older strata and many different fault systems. From 2D Seismic Interpretation of GTJ89-503, GTJ89-510, GTJ89-508 and GTJ89-512 is performed from synthetic seismogram correlation 3-Reflector are marked Ranikot (Paleocene) ,Lower Goru Formation. The subsurface structure are show Normal Fault with the the small throw and are related to extensional environment. The younger strata show the slides activation of older faults.

1) Time depth contour map of Lower Goru Formation conformed the presence of Normal faulting

2) Rock Physics analysis from well log show the potential zone Lower Goru Formation.
3) Petro physics analysis show Lower Goru Formation in some interval act as reservoir

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