International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878, Impact Factor (2014): 3.05

Basics of Land Seismic Data Interpretation

Kulbhushan[1*], Monalisa Mitra[2]**

[1]Kurukshetra University, Kurukshetra, Department of Geophysics, Haryana, India, Pin-136119
[2]Burdwan University, Department of Geology, Durgapur, West Bengal, India, Pin-713214

*Present Address: ALPHAGEO (India) Limited, 6-3-250/2, Road No.1, Banjara Hills, Hyderabad-500034, India
**Present Address: Haryana Space Application Center (HARSAC), Department of science and technology, CCS HAU Campus, Hisar-125004, Haryana, India

Abstract: ***2D and 3D seismic data have been used to delineate a productive zone in Assam oil field of India. The research involves basic steps required for 2D and 3D land seismic data interpretation both by hand and workstation, and how it can be successfully utilized in delineating hydrocarbon bearing structural traps and the general geology of the concerned area.***

Keywords: Seismic data, Structural Maps, Anticlines, Faults, Horizon

1. Introduction

Some of the common geophysical survey techniques used in oil and gas exploration to know the subsurface image are Gravity survey, Airborne gravity survey, Magnetic survey, Airborne magnetic survey, Electromagnetic survey and Seismic survey. Details of geophysical techniques are not emphasized; these are covered in standard texts [1] and have been summarized in [2].

Among all these methods seismic method is manifested the most important indirect method for collecting information about the Earth's geological structures and rock properties. It can be used inland, offshore, and in transition zones. Though details of the seismic method are complex, the principle is relatively simple. Seismic sources at or just below the surface generate elastic waves that propagate in different directions through the subsurface. Variations in the physical properties of the geological layers cause the seismic signals to reflect, refract at the boundaries of these layers. The reflected waves head back towards the surface where detectors have been placed to record these waves. The recorded signals are subsequently processed to generate images of the subsurface, and to estimate physical properties such as wave velocity.

In marine environment, the seismic signals are either generated by an impulsive source, known as the air-gun, or by some controlled vibratory source as a coded signal. The returning signals are detected by piezoelectric pressure sensors called hydrophones which are connected in streamers (measurement cables) towed by a boat. Alternatively the velocity and acceleration sensors are placed on the sea floor to detect the returning signals by ocean bottom cable (OBC) surveys. In the land survey on the other case seismic signals are generated either by dynamite sources or by mechanical impulsive sources or by coded vibratory sources. The returning signals here are detected by either velocity or acceleration sensors known as geophones.

With phase of time seismic method has been significantly improved since its start in the early twentieth century. Previously Two-dimensional (2-D) seismic data were primarily used for exploration as well as interpolation between wells during the production phase. In 1980's three-dimensional (3-D) seismic data interpretation was first introduced. This brought a revolution in exploration industry. Results revealed that 3-D seismic data provide significantly better images making detection of small-scale reservoir features like channels, small faults or fractures easy. Currently, 3-D seismic data are not only used during the development phase, but also they are used during the exploration phase resulting in reduction in acquisition cost. Significant attention to wide-azimuth marine 3-D data is given which assist in improving complex subsurface imaging [3] [4]. Wide-azimuth land 3-D seismic data has been widely used in improving imaging in areas with complex near-surface [5]. With the advent of technology we are now even more advanced and are recently using four-dimensional (4-D) seismic data or time-lapse data, which proved to be very useful in monitoring reservoir fluid movements with time in particular for the marine case. The use of multi component (i.e. compressional and shear waves) seismic recording has opened new opportunities for more accurate estimation of the rock properties. In order to start a seismic survey we first need to study the detail geology of that specific area and collect as much information as possible i.e. determine the rock formations, traps present in the area and also stratigraphy of the required area. We can get this information by the previous surveys or studies that have been performed in this area. Then we go for the Gravity survey using the instrument gravity meter. This in turn helps us to determine the anomaly and mainly the depth of the bed rocks; also we can determine the strike and dip of the anomaly using the gravity contours of the interested area. These strike and dip information helps in plotting the map where to laid the source and receiver line. After all this information is acquired we start the process of Seismic Exploration.

Seismic Exploration is basically a technique to map the subsurface geology. It consist of three main steps namely data acquisition, data processing and data interpretation. Data acquisition is the fundamental base of this technique. To start data acquisition, simulation is done and the field parameter i.e. we design the survey is set. Then we artificially shot the design in the software and check the requirement. Inaccuracy while acquiring data, may lead to wrong interpretation. Better results can be obtained if data quality is good enough. Data should be acquired after the other preliminary surveys, taking all the precaution into consideration like noise test, proper source and proper arrangement of all the geophone groups to attenuate the noise part. If possible, go for the 3-D survey technique as it provides resolution, depth accuracy and lateral extent of the reservoir. Marine surveys are easy to perform as noise part is comparably less and data can be acquired with faster rate, which make it less expensive. Data is acquired in digital format and whole work is done through computers, so results can be obtained in a less span of time.

After collecting the data we process the raw data. As the noise cannot be removed completely during the acquisition so to get the pure data and go for various operations as discussed in processing part. During the processing our main aim is to enhance the signal to noise ratio using the mathematical operation. After process the data we go for the interpretation.

2. Location and General Geology of Study Area

The study area is situated in Assam, located in the North Eastern region of India. It has a diversified geological spectrum. It is located near the hairpin bend of the Himalayas. Hence the extreme geostatic pressures exerted on the landmass during the creation of the Himalayas have resulted in Assam having large areas of sedimentary deposits. These in turn have resulted in huge amount of hydrocarbon deposit in places like Digboi, Bongaigaon etc. Apart from this Cachar district of Assam is a huge storehouse of limestone. This primary sedimentary rock is used in construction; interior decoration etc. The famous Dhubri district has an approximate reserve of more than ten million tons of Iron Ore. Of the four kinds of Iron ore, Haematite, Magnetite, Limonite and Siderite, the region is predominant in Haematite deposits. Karbi, Anglong District and North Cachar hills have substantial reserves of coal. Of the four types of coal namely Peat, Lignite, Bituminous and Anthracite, the third kind is readily available out here. Karbi, Anglong is also rich in Kaolin (China Clay) deposits. Another district, Morigaon, contains extensive reserves of granite. Not to be outdone, Nagaon district has got very high reserves of Glass Sand. Thus it can be said that the geology of Assam depicts a rich repository of minerals with its diversified geographical structure.

3. Methodology

Two types of methodology were followed.

3.1. Mapping and Contouring Manually

Mapping and Contouring of Horizons on paper of Seismic Sections for interpretation of 2-D seismic data (Manually). Although the contouring process can be mechanized, many interpreters prefer to contour by hand in any situation where these interpretive decisions are critical. The operations of timing and posting, however, are not interpretive; they can and should be mechanized. Today contouring is generally done by machine. But sometimes the machine fall short. It is then where comes the skill of not only making contour maps but also correct reading of contour maps made by others, so that from the two-dimensional contour map the three-dimensional surface can easily be visualized. Within a minute or two, the expert interpreter can identify the structural style, the location of the trap, the location of the spill point, and the structural risk in the prospect.

A part of seismic data was taken for the 2-D Interpretation work. The block consisted of 8 parallel in lines and 2 cross lines each representing a seismic section. Basic rules were followed to interpret the data.As no well data was present for given data, so two horizons were taken into consideration.Firstly one horizon was picked on one line section and then the same horizon had to be picked forthe rest of the parallel sectionsthus making it easy to compare.Also it was made sure that at the intersection points of Inline and crossline time of same horizon will be same. Now the horizon can be smoothly marked across all the sections.Similar steps were followed for the second horizon.

After thehorizons weremarked on all the sections contouring of the horizon was done. For this the shot point interval and corresponding two way time for all the sections were taken. Now all the time values were transferred on the base map. Also note that at the intersection points the time of same horizon will be same.After transferring all the values if the time was same for all the intersection points, then we can say that the horizon was same for all sections.With free hand all the points having same values were joined to get the desired contour. Thus contour map as shown in **figure-1**got prepared. Once the contour map was prepared by looking at it we inferred some faults that were present in the area. The geology of the area was also very clear.

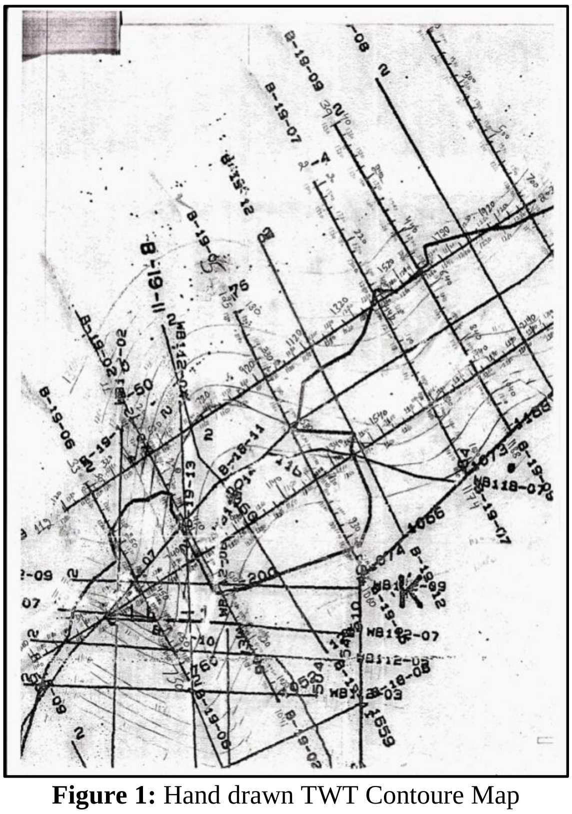

Figure 1: Hand drawn TWT Contoure Map

3.2. Interpretation on Workstation

The main objective of interpretation on workstation is the mapping of the two horizons. One near the basement and the other at the top of the Oligocene layer, then study the fault pattern of the area.

A block consisting of 24 fold 3-D Data of Assam with a Bin size 25 x 50 m was processed using ProMAX Software. It was then interpreted using GeoFrame Software in Work Station.

Table 1: Details of the data

Project location	Assam
Area	102 km^2
Inline Interval	50(m)
Cross line Interval	25(m)
First Inline	1204
Last Inline	1373
First Cross line	1266
Last Cross line	1749
Inline Increment	1
Crossline Increment	1

3.2.1. Data loading and Writing Devices used:

1. Cartridge Drive also known as SDLT Drive
2. Two types of Tape Drive, DAT Drive (4mm) and EXABYTE Drive (8mm)

3.2.2. Data Storage Devices used:

a) Cartridge with data storage capacity from 10 GB to 800 GB
b) 4 mm and 8mm Tape
c) CD
d) DVD
e) Floppy
f) USB Storage devices (Like Pen Derive)

3.2.3. Software and Hardware used:

a) Software

GeoFrame 4.3 and Petrel 2007.1.2
Software's GeoFrame is a Linux and Sun Solaris operating system based.

Petrel is a Windows operating system based.

b) Hardware

Workstations of HP and SUN with 400 GB hard disk capacity, 16GB RAM and 64 bytes/s data transfer rate.

3.2.4. Loading of Seismic and Navigation Data

Project Creation- A Project is created for loading the 3-D Seismic Data in workstation so that it can be Interpreted using GeoFrame Software.

Navigation Data Loading- In Navigation data all the Easting and Northing (X, Y) information of CDP and Short Point are present which are loaded in my project file.

SEG Y Data Loading- The given 3-D Seismic Data (SEG Y) is loaded from an 8mm EXABYTE Tape.

Merging-Now after loading of Navigation as well as SEG Y Data it is merged together so that our SEG Y Data has its Navigation.

With the above available data the following methodology was followed for horizon picking, fault identification and 3-D seismic data interpretation.

3.2.5. Mapping Horizons and Contouring on workstation with software.

Three In-lines 1302, 1330 and 1365 were selected to plot two horizons, one near the basement and the other at the top of the Oligocene layer as shown in **figures-3 to figure-5**. Once those horizons were picked its values were used in the software to interpolate the horizons across the survey area for plotting the Contour Map, as shown in **figure 6**.

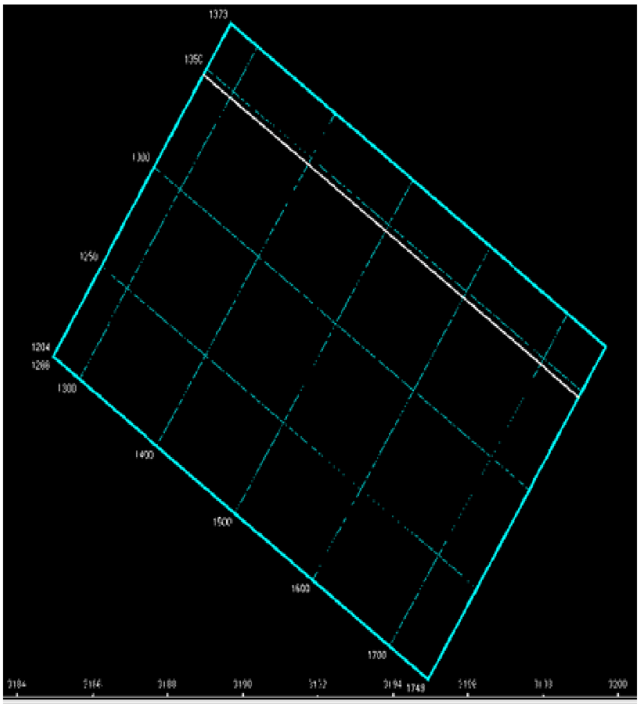

Figure 2: Base map

ISSN (Online): 2347-3878, Impact Factor (2014): 3.05

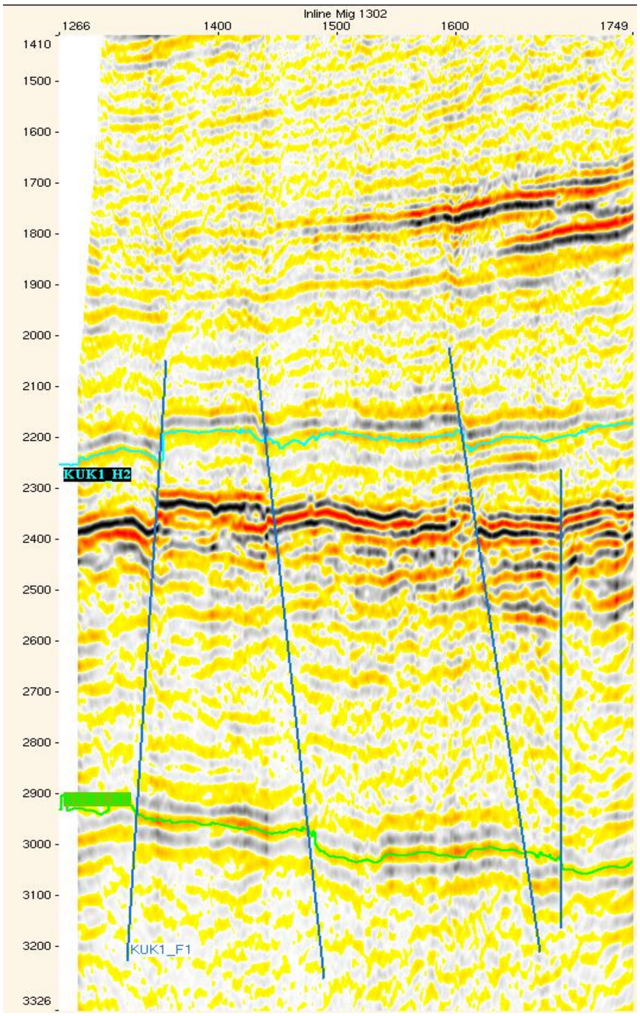

Figure 3: Seismic section I

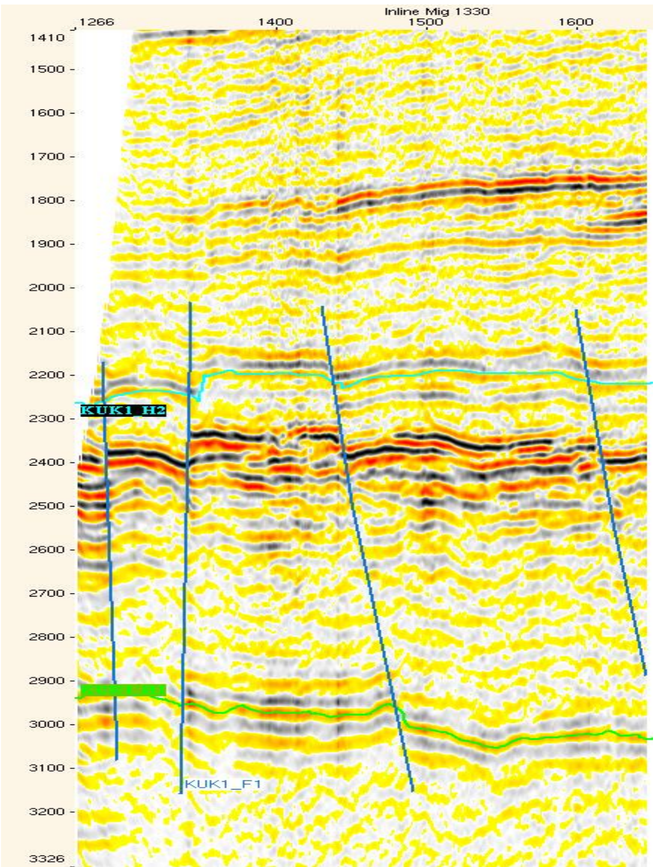

Figure 4: Seismic section II

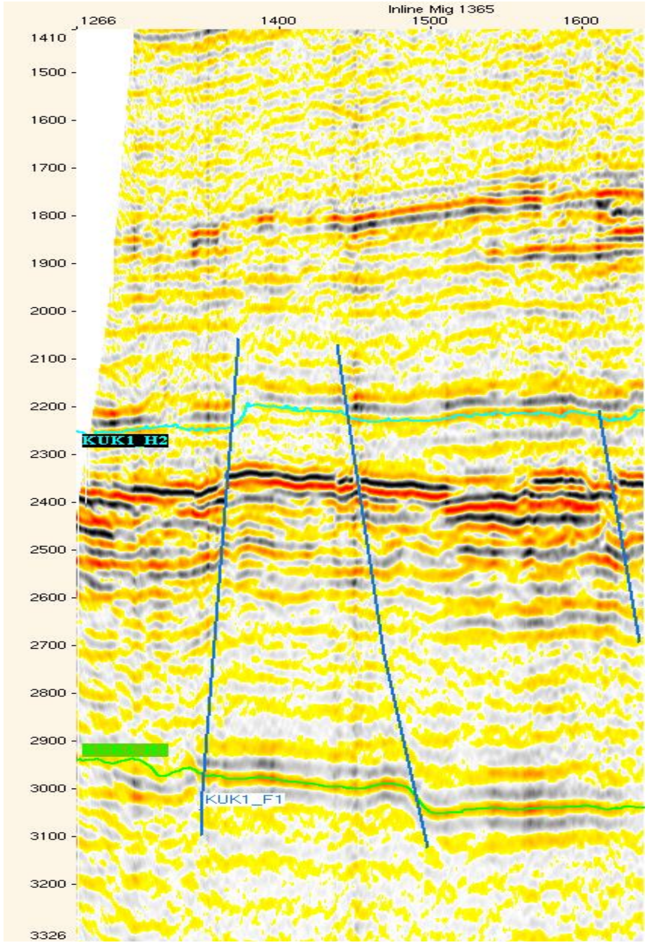

Figure 5: Seismic section III

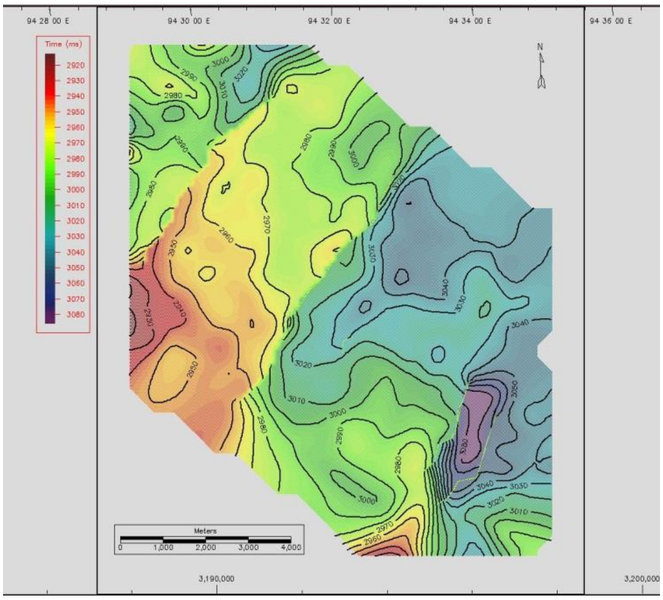

Figure 6: TWT Contour Map

4. Result and Discussion

4.1. Mapping and Contouring Manually of 2-D Seismic data

The result that came out from the contour map generated as shown in figure 1 is as follows:

a) In the present block area there was one tight anticlinal closure in SE part of block.
b) The synclinal body corresponding to faulted anticline present in the block lying in central part of the block.
c) A major fault, trending NE-SW was present. Also there were two minor faults present in NNW part of block.

4.2. Interpretation of 3-D Seismic Data in Work Station

The result that came out from the contour map generated as shown in figure 6 is as follows:

a) Interpretation of time structure map: trending NW-SW
b) Two major NE-SW faults have been observed with in the block.
c) A fold closer has been observed against a fault trending NE-SW.
d) A horst Feature is observed between the two faults.
e) Two way time of Horizon varies between 2930 to 3080 M.sec. This block shows low trends toward the western part of the contoure map and also we see another small low trend patch at the southern part of the map.

Acknowledgement

This study was a part of my dissertation work which was performed at Director General Of Hydrocarbon (DGH), Noida, and I am greatly obliged to **Mr. B. J. Praveen Kumar** Senior Advisor (Geophysics), DGH Noida and **Mr. Rajedra Gahlawat** Trainee Geoscientist, DGH Noida for helping me complete my study and obtain a degree. I am also grateful to **Dr. S. S. Teotia** and **Dr. Bhagwan Singh Chaudhray** Professor, Department of geophysics, Kurukshetra University for guiding me to prepare my dissertation report work.

References

[1] Society of Exploration Geophysicists, 1966, (1967), Mining Geophysics, v. 1, Case Histories; v. 2, Theory: Tulsa, Society of Exploration Geophysicists, 492 p. (v. 1); 708 p., (v. 2). 1990, Geotechnical and environmental geophysics, v. 1, Review and Tutorial; v. 2, Environmental and Groundwater, in Ward, S.H., ed., Tulsa, Society of Exploration Geophysicists, 389 p., (v. 1); 343 p., (v.2)
[2] Hoover, D.B., Heran, W.D., and Hill, P.L., eds., 1992, The geophysical expression of selected mineral deposit models: U.S. Geological Survey Open-file Report 92-557, 129 p.
[3] Moldoveanu, N., and Egan, M., 2006, From narrow-azimuth to wide- and rich-azimuth acquisition in the Gulf of Mexico: First Break, 24, 69-76
[4] Long, A., 2006, How multi-azimuth and wide-azimuth seismic compare: First Break, 24, 55-61.
[5] Hastings-James, R., Green, P., Al-Saad, R., and Al-Ali, M., 2000, Wide-azimuth 3-D swath acquisition: GeoArabia, 5, 103

Author Profile

Kulbhushan received M.Tech degree in Geophysics form Kurukshetra University, India in 2008 and is also got a MBA on 2012 from EIILM University Sikkim, India. Joined Fugro Geoscience India Pvt. Ltd. as QC Processor from September 2008 to November 2011.After that joined ION-GX Technology from December 2011 to December 2014 as Senior Field Geophysicist. Presently working as Senior Seismologist with AlphaGeo India Limited

Monalisa Mitra received B.Sc and M.Sc degree in Geology with specialization in Hydrogeology, Remote sensing GIS from Burdwan University, India in 2009. Joined as Project Assistant at Oceanography Department, Jadavpur University and worked there till December 2010, later joined West Bengal State Council of Science and Technology, Department of Science and Technology, Kolkata, Government of West Bengal as JRF. Presently working as Project Assistant at Haryana Space Application Center, India