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# Seismic Events Identification below the Surface by Using 3d Seismic Data Acquisition and Processing Techniques in Ramnad Sub-Basin, Chennai, ONGC



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#### **INTRODUCTION:**

The survey is being carried out in Ramnad sub-Basin, a part of Cauvery sub basin in eastern coast of India in Tamil Nadu State. The data is being acquired by Geophysical party No.11 & Geophysical Party No. 04 in the area of 163 sq km.

#### **OBJECTIVE:**

GP 4 & 11 are acquiring 3D Seismic Data in Ramnad Area (M163) with the primary objective of Strati-Structural configuration of Andimadam formation and secondary objective of Strati - structural configuration of Bhuvanagiri & Nannilam formations and Basement configuration.



#### **SEISMO-GEOLOGICAL EQUIVALENTS:**

| Parameter              | Primary           | Secondary         |
|------------------------|-------------------|-------------------|
| Depth zone of interest | 2700 m - 5000 m   | 1800 m - 2600 m   |
| Time zone of interest  | 1950 ms - 3050 ms | 1400 ms - 1900 ms |
| Bin size               | 20m X 20m         |                   |
| Dip                    | < 5°              |                   |
| Fold                   | 60 +              |                   |

#### **EXPERIMETAL WORK:**

Uphole surveys are conducted to identify and demarcate high velocity compact medium for effective transmission of energy. The primary aim of uphole surveys is to determine the optimum depth (OD) i.e. the depth at which the charge should be placed for shooting with minimum energy dissipation.

In M163, Upholes are conducted with 2 km×2km interval. Holes are drilled to a depth of 60 m. The general criterion is that uphole depth should be 1.5 times of the maximum prepared OD. A winch in which electric detonators are connected is lowered in to the hole. Single analog geophones are planted at an offset of 1m, 3m, 5m, 50m and 75m from the hole. Observations are made at an interval of 1m in interested depth and remaining depths with 2m interval. Drilling for Uphole & Survey Layout of Uphole are as shown in the fig., 3.1& 3.2 respectively.



Drilling truck used for drilling



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#### **SEISMIC DATA ACQUISITION:**

Recording truck Equipments: The Central Recording System (CRS) includes ruggedized computers mounted on shock-protected chassis. The central software provides a user-friendly interface for the operator to visually manage the ground electronics, sources and the data quality control of the acquisition. The Truck Interface Module (TIM) connects the seismic spread to the CRS, encompasses six built in auxiliary channels, and allows for two sources controller connections at the same times.



#### LOADING AND SHOOTING:

SHOT HOLE DRILLING: Shot holes are drilled to a depth ± 2m of OD in their respective position. Drilling can be done manually or mechanically using hydraulic drilling machines. Hole collapse may occur due to loose formations at some depth.

This is prevented by mixing bentonite powder with the drilling mud, and it forms a thick layer on the walls of the well, thereby preventing its collapse.

#### **SHOOTING STRATEGY:**

Shooting is the process of detonating the charge loaded in the shot holes. Communication between shooting crew and instrument control for detonation is done through Shot Pro –II shooting system.

When all channels are active command is given from the control and the charge is detonated by the crew. Cars and trucks traveling close to the line spread should be shut off to reduce the noise on recorded data.



### Geophone Bunch:

This is the sensor part used for effective recording of seismic signal. It is three component digital sensor module, having MEMS (Micro-Electro Mechanical System). Up to 3 can be connected to each D-unit cable, which are unit take-out and side take-outs.

All control, power and data return signals from each sensor module pass on a two-wire interface to the D-unit.



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#### **DATA RECORDING:**

The seismic data is recorded in digital form and is stored in LTO Cartridges and also in External hard disks. The data brought from the field is copied in DDR (Digital Data Recorder) and is analyzed daily. The dead and spiky channels were analyzed and the daily statistics is recorded. The data is also loaded in FPU (Field Processing Unit) and used for the generation of frequency spectrums.



#### DATA SUBMISSION TO RCC: SPS (Shell Processing Support):

This is the universal format that should maintain for seismic data acquisition. It has R-file (Receiver file), S-file (Source file) and X-file (Relation file). In R-file receiver picket number and its corresponding coordinates exist. S-file consist of shot point number its coordinates. X-file shows the shot point for which receivers are active.From MESA we can generate SPS and this is used as SPS input to instrument for acquiring data. This SPS is automatically updated from the instrument. After the completion of line the SPS is taken from instrument. Actual coordinates of receivers and shot points are received from survey section. By using the survey coordinates and the instrument SPS out, final SPS for the line is prepared and is sent to RCC for processing along with the Data Cartridge and Hard copies of observer report.

#### FIELD PROCESSING:

Before sending the prepared SPS to RCC (Regional Computer Centre) raw data is merged with SPS in FPU. Then shot point and receiver quality check is done.



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### Data load to FPU hard disk:

Step involved are SEGIN module for external tape, SELTR for P-wave selection out of three components, MODET for renumbering of P-wave as 1, 2, 3...etc. instead of 9, 12, 15...etc. FILTR is normal broad band filter (8, 12—60, 70 in Hz) and last monitor shows FPU hard disk.

#### **SEISMIC DATA PROCESSING:**

Improved in the both in the areas of data acquisition and processing. Digital recording along with the CMP multifold coverage was introduced during the early 60's. Data acquired from the field are prepared for processing by the field party itself and then it is send to the processing centre. Processing is required because the data collected from the field is not a true representation of the subsurface and hence nothing of importance can be inferred from it.

### **Objectives of Data Processing:**

The objectives of data processing may be summarized as follows:

1) To enhance the signal to noise ratio (S/N).

2) To produce seismic cross section representative of geology.

3) To meet the exploration objectives of the client.

### **Basic Processing Sequence:**

There is no standard/routine processing sequence that will fit every seismic survey acquired in every part of the world. The processing sequence must be designed according to the area problems and record quality. But there is an outline that must be followed.





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## Loading of the Data:

Seismic data acquired from the field was prepared for processing by the field party itself and then sent to the processing centre in Cartridges. The data in the field tapes had to be loaded into the system for processing. This process is called "loading of the data." Reformatting: Data recorded in the field may not be in the format required by the processing centre. At this stage the data has to convert to a convenient format that is used throughout the processing. This format is determined by the type of processing system and the individual company.

## Raw data loading:

Since modern seismic recording systems supply field data in Demultiplexed form, presently Demultiplexing of data is not required. But in case of reprocessing of old data, this demultiplexing of seismic data is necessary.



### Editing involves the following steps

- \* Trace Killing
- \* Muting
- \* Filtering



Mono-frequency & Noisy traces.

## Trace killing:

Trace kill is the option for, removing the bad traces. So by trace kill operation we kill/remove the bad traces.

## **Muting:**

This is the process of excluding parts of the traces that contain only noise or more noise than signal. High amplitude noise events such as ground roll, direct waves which show up on specific time segments of the data trace are removed through a process called muting.

### **Reverse trace:**

During acquisition some reverse traces are obtained, due to some erroneous connections in the field. These can be taken care by reversing those traces.

## Frequency filtering:

### **Spectral analysis:**

Spectral analysis gives the frequency range of our data. In spectral analysis we have graph between power in decibels (dB) and frequency in hertz. Frequency filters are the most important filters in seismic signal processing. The energy of reflections is most of the time, present in a certain frequency range.

The specific source noise and background noise are commonly present in a different frequency range and a separation of noise and reflection information to some extent is possible by frequency filter. To limit the frequencies to the seismic range a band pass filter is conventionally applied.



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## i) Band Pass filtering:

The property of band pass filter is that it will preserve the frequency spectrum within the specified range and cut off the frequencies above and below it.

On the basis of interactive spectral analysis, the frequency range of the band pass filter was selected as 3-8Hz to 80-90Hz, because the signal lies within this range only.

## ii) F-K filtering:

In seismic gather many coherent dipping events are observed which are not of our interest. Since the frequency components of these events overlap the seismic frequencies, this noise cannot be suppressed by normal frequency filter. However the waver number is dependent on the dips so such events can be removed by using F-K filtering. The f-k filtering is also termed as Velocity filtering.



**BEFORE NOISE EDIT** 

## True Amplitude Recovery (TAR):

As the signal travels away from the Source, it becomes weaker. This decrease in amplitude of the signal with distance from source is called "Attenuation". There are various factors, which affect the attenuation of seismic waves. It is partly due to the geometry of propagation of seismic waves and partly due to inelastic properties of the material through which they travel and also due to transmission losses. TAR compensates for above mentioned losses. By the application of TAR we get the enhanced deeper reflections. The combined loss in the amplitude due to Spherical Divergence and Inelastic attenuation is A=Ao ro/r.e - (r-r)

**AFTER BAND PASS FILTER** 

Where, A = amplitude at distance 'r' from the source Ao = amplitude at distance 'ro' from the sourc-

es

AFTER MANUAL EDIT

= absorption coefficient



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### **Static Corrections:**



Sheriff's definition of static corrections, often shortened to statics, is as follows."Corrections applied to seismic data to compensate for the effects of variations in elevation, weathering thickness, weathering velocity, or reference to a datum"

## **Deconvolution:**

Deconvolution is a inverse filtering process which removes a wavelet from the recorded seismic trace by reversing the process of convolution. The commonest way to perform deconvolution is to design a Wiener filter to transform one wavelet into another wavelet in a least-squares sense.

If wavelet were a spike, then only the earth's impulse response would be recorded. This impulse response comprises primary reflections and all possible multiples (noises). Ideally speaking deconvolution compresses the wavelet components and eliminates multiple, leaving only the earth's reflectivity in the seismic trace. This convolution model of the recorded seismogram may be represented as below.

X(t) = w(t)\*e(t) + n(t)

Where X(t) = recorded seismogram, W(t) = basic seismic wavelet,

E (t) =earth's impulse response, N (t) = random ambient noise

The mathematics of predictive deconvolution require that the autocorrelation of the source wavelet is known. Since this is rarely true in practice the autocorrelation of the seismic trace is used as an approximation instead. The autocorrelation function is critical in picking the deconvolution parameters of gap (also called minimum autocorrelation lag) and operator length (sometimes called maximum autocorrelation lag). Some contractors refer to the total operator length as the length of the gap plus the operator length, others refer (ambiguously) to this as the operator length.



## Common Depth Point (CDP) Gather:

The general idea of the method is to acquire a series of traces (gather) which reflect from the same common subsurface mid-point. In the fig.3.13 source points and receiver positions are shown. The traces are then summed (stacked) so that superior signal-to-noise ratio to that of the single-fold stack results.

The fold of the stack is determined by the number of traces in the CMP gather and the spacing between geophones i.e. group interval and shot interval. The Field data is recorded in "Shot Gather" mode i.e. for any record the shot is common for all traces. But in Computer Center Seismic data processing is done in "CDP Gather" mode i.e. all the traces pertaining to a given Common Depth Point (CDP) are grouped together.



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## **Velocity Analysis:**

After generating the Brute stack, the further processing aims at refining the seismic output (stacks) further. The Seismic velocities vary vertically as well as laterally and hence they need to be properly estimated along the line to apply proper corrections (NMO) and obtain the optimum stacks. From this panel, velocity functions are estimated at every Kilometer or less along the seismic line. The "Uncorrected gather" is NMO corrected using the picked velocity function. If the velocity function is correct then all the "Primary reflection events" straighten after the correction. If the reflections show some curvature even after the NMO correction, then the velocity function is modified till all the major reflections align properly.

### **Migration:**

Migration is the process of reconstructing a seismic section so that reflection events are repositioned under their correct surface location and at a corrected vertical reflection time. Migration also improves the resolution of seismic sections by focusing energy spread over a Fresnel zone and by collapsing diffraction patterns produced by point reflectors and faulted beds.

The conversion of reflection times recorded on nonmigrated sections into reflector depths, using one-way reflection times multiplied by the appropriate velocity, yields a reflector geometry known as the record surface. This coincides with the actual reflector surface only when the latter is horizontal.

In the case of dipping reflectors the record surface departs from the reflector surface; that is, it gives a distorted picture of the reflector geometry.

### **How Migration Works**

Consider a source–detector on the surface of a medium of constant seismic velocity (Fig.3.21). Any reflection event is conventionally mapped to lie directly beneath the source–detector but in fact it may lie anywhere on the locus of equal two-way reflection times, which is a semi-circle centred on the source–detector position.



## Post-Stack vs. Pre-Stack Migration:

Migration of seismic profile data is normally carried out on CMP stacks, thus reducing the number of traces to be migrated by a factor equal to the fold of the survey and thereby reducing the computing time and associated costs. Migration of stacked traces is based on the assumption that the stacks closely resemble the form of individual traces recorded at zero offset and containing only normal-incidence reflection events. This assumption is clearly invalid in the case of recordings over a wide range of offsets in areas of structural complexity. A better approach is to migrate the individual seismic traces (assembled into a series of profiles containing all traces with a common offset), then to assemble the migrated traces into CMP gathers and stacks. Such an approach is not necessarily cost-effective in the case of high-fold CMP surveys, and a compromise is to migrate subsets of CMP stacks recorded over a narrow range of offset distances, and then produce a full CMP stack by summing the migrated partial stacks after correction for normal moveout.



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Procedures involving migration before final stacking involve extra cost but can lead to significant improvements in the migrated sections and to more reliable stacking velocities.

#### Frequency-wavenumber Method (F-K Migration):

As tan  $\alpha = \sin \beta$ , this equation provides the basis for frequency domain migration. If velocity is constant, lines in x, t space that have the same slope (same apparent velocity or same apparent wavenumber) transform by the 2-D Fourier Transform into a single line in kx,  $\omega$  space figure 3.27(b); the separate parallel lines in x, t space are distinguished by different phases in kx,  $\omega$  space. Frequency domain migration changes the slope of lines in kx,  $\omega$  space according to Eq. (1). The inverse transform then gives a migrated section in x, t space Thus conceptually, frequency domain migration becomes simple operation.

#### **CONCLUSION:**

Main objective of the data processing was to identify the seismic events present below the surface starting from the raw data acquired in the field, by means of sequential processing techniques. Initially, the field geometry was generated by merging the SPS data and updating the trace headers with elevations, shot & receiver co-ordinates, shot statics, receiver statics etc.

Deconvolution was one of the most important step carried out in seismic data processing. It improved the temporal resolution by collapsing the seismic wavelet to approximately a spike. Also, it was used for suppressing multiples and reverberations. Velocity analysis which was another important step in data processing was required to know the subsurface velocities, which helped us to remove the effect of offsets (i.e. NMO correction) and brought the events at a common time. Stacking was an important method for improving the signal-to-noise ratio and mainly used to suppress the random noise. Migration was applied to the stacked section to get the actual position of the reflectors and thus to get a seismic section similar to a geological section that would be ready for interpretation. Thus, the Processing Geophysicist acts as a bridge between the Field Geophysicist and the Interpreting Geophysicist.

#### **References:**



#### Ravi Chandra Kammula

Assistant Professor (Geophysics) Also Honorable Persons Mr.B.S.josyulu (E.D), Basin manager , Mr. B.S.N Murthy GM (GP), Mr. A. Gangaiah DGM (GP), Mr. S. Dutta Chief Geophysicist, Dr. R. L. Basak Chief Geophysicist(S) of RCC, ONGC Chennai and Party Chief of GP 11 Mr. Shri. Sansar Singh CG (S) & Party Chief of GP4 Mr. Shri. Suman for sharing their valuable experiences during teaching throughout the training period.