Measures taken to improve seismic data quality during acquisition in Jotana Mewad area of WON basin, Gujarat

H.N.Garg,ONGC*
garg_hn2006@yahoo.com

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Summary:

The objective of seismic data acquisition is to map the various geological features present in the area at various depths of an assigned area. With the focus of geological objectives shifting to more complex and subtle features, the need to sharpen the survey parameter design process and meticulous monitoring require higher level of team work and dedication.
The economic value of the seismic data is enhanced through acquiring high resolution data which will map the various geological features with authenticity and help in reducing Dry Wells and identification of New Prospect / New Pay.
To improve data quality, control and checks during all the processes involved in the data acquisition stage ensure a better product.
In Jotana Mewad area oil/gas pool has not been established. The area is surrounded by number of oil and gas fields with the known reservoirs in Mehsana and Mandhali formations (Fig.1).

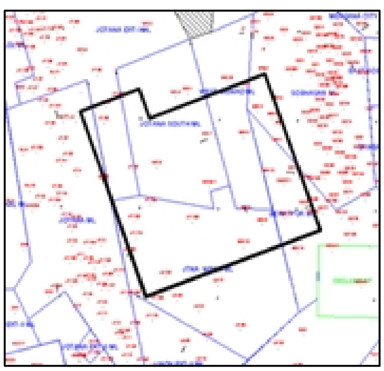


Fig. 1: Jotana Mewad area

The operational area is surrounded by producing fields, Sobhasan in eastern and Jotana in western side and Linch in south western side. Warosan Low is falling in N-S direction along the center of the operational area. Western rising flank of Warosan low is particularly highly prospective. Recent success of wells in NW part of the area and in SW part of the area proved that Mehsana and Mandhali are prospective pays in the area.

New pools of oil and gas are to be discovered in Jotana Mewad area by probing deep into mother earth from Mandhali and Linch formations. From the old seismic data these formations could not be mapped with higher degree of confidence. Therefore, high resolution 3D seismic data having high frequencies at deeper level was required in Jotana Mewad area.

A 3D seismic survey was undertaken with an objective of mapping better seismic image of strati-structural features within Mehsana, Mandhali pays. The primary objective was to map Mehsana and Mandhali pays with high resolution at a depth of 1100m to 2300m. The secondary objective was to map deeper prospects in Linch formation present at a depth range of 2300m to 3500m.

To improve data quality Asymmetrical Split Spread geometry with shooting from both ends was designed, real time recording of shot and receiver coordinates were undertaken and emphasis was given on use of large offset in designing of geometry through modeling studies. FTB, NTG and LMO were prepared. Use of higher number of channels, recovery planning and use of state of art technology etc. helped in improving data quality.
Frequent Interaction of user group with data processing group and QC group has added value to the data.

1. Introduction

Elements of Good Signal

1. Good Signal to Noise Ratio
2. High Resolution Power
3. Adequate Spatial Coverage

During acquisition, high S/N is achieved by maximizing signal with a seismic source of sufficient power and directivity, and by minimizing noise.
It distinguishes the top and bottom of the reflectors and quantifies the strength of the reflection. This is achieved by recording a high bandwidth, or wide range of frequencies. The greater the bandwidth, the greater the resolving power of the seismic wave.

The steps taken for quality improvement of the data are:

1. Planning
   a. Geometry Design - Use of Asymmetrical Split Spread with shooting from both ends
   b. Modeling studies.

2. Use of state of art technology
3. Field Efforts
   a. Online recording of shot and receiver coordinates.
   b. Preparation of FTB, NTG and LMO
   c. Ground coupling
   d. Preparation of Near Surface Models
   e. Online & special recovery
   f. SPS checking
4. Processing

All the above steps have helped in generating good quality sections which are better than the benchmarked data.

2. Methodology

2.1. Geometry Design:

Various acquisition geometries have been designed and analyzed for assigned target and objectives using MESA software platform. Finally three acquisition geometries, G1, G2 and G3 have been selected for detailed comparison (Table 2).

Table 2: 3D geometries for comparison

Geometry/ Parameter	ASS with shooting from both sides	ASS with shooting from both sides	End on
Number	G1	G2	G3
Bin (m)	20*20	20*20	20*20
Fold	10*6=60	10*6=60	10*6=60
NR/L	180+40=220	40+160=200	180
NRL	12	12	12
MO	3968	3610	3968
RLI	200	200	200
SLI	440	400	180

2.1.a. Evaluation of geometry

The geometries were evaluated on unique offset fold, azimuthal coverage, percentage of bins falling in the zone of interest (Figs. 2-5).

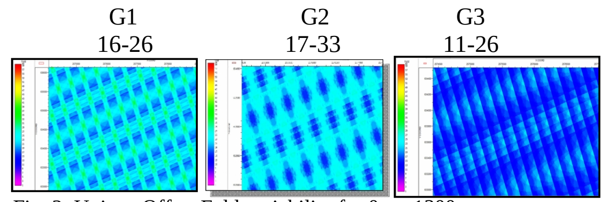


Fig. 2: Unique Offset Fold variability for 0 m -1300 m

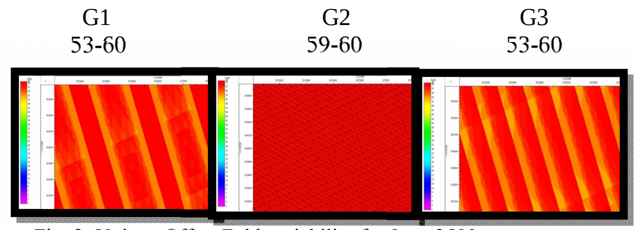


Fig. 3: Unique Offset Fold variability for 0 m -3500 m

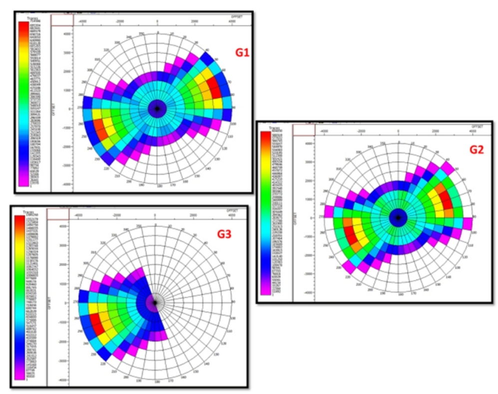


Fig. 4: Rose diagram for 3500 m

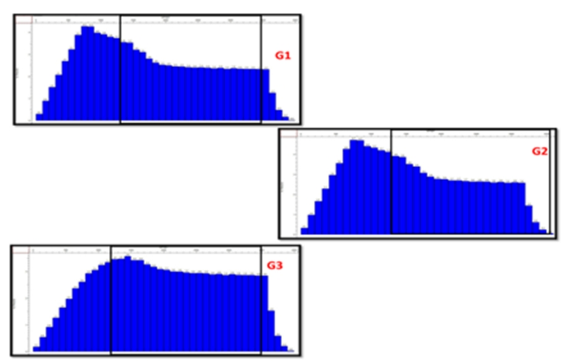


Fig. 5: Percentage values for Offset distribution of 3500 m

Asymmetrical Split Spread (ASS) with shooting from both ends was found to be more effective. G2 geometry is selected as it has consistent unique offset fold variability, better availability of offsets in all directions.

2.1.b NORSAR modeling

3D modeling on NORSAR software was carried out to generate illumination maps for the deepest horizons in the area (Fig. 6). Depth contour maps within Kalol Top, Coal Top, Coal bottom, Mehsana, Mandhali and Linch Top were used for modeling. Acoustic impedance was generated in the three layers using velocity and density data from well logs. The geometry G2 was processed to generate illumination maps (Fig. 7).

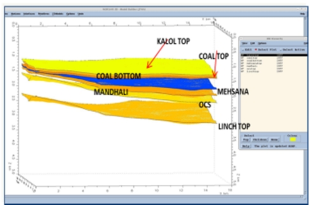


Fig. 6: Different horizons

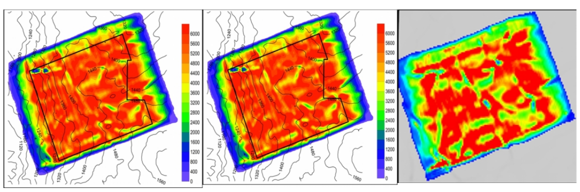


Fig. 7: Illumination maps of Mehsana, Mandhali, Linch top

2.2 Use of Technology:

The state of art instruments were used to mitigate risk and improve quality. The improvements in the instruments of Surveying, Data recording were utilized. The Field Processing Units, Mobile Processing Unit, GEOLAND, SUPPLANT, MESA software's' for designing of field geometry and modeling of complex geological set up had improved quality.

2.2.1 Surveying: The DGPS (Differential Global Positioning System) gives easting, northing and elevation of the pickets in cm accuracy after applying the Carrier Phase corrections. The GIS (Graphical Information System) and Remote Sensing data are being used to calculate positioning of shot points and recovery points well in advance before moving to the actual location. The survey planed in advance improved data quality.

2.2.2. Seismic Data Recording

2.2.2.a Geophones: The P-wave moving coil geophones (marshy and land type) used to acquire consistently good quality data. The tighter specifications were used to acquire good quality data. The bad geophones were weeded out, collected and sent to field lab by afternoon for repair and testing. The geophones were redeployed after stringent quality check at the lab.

2.2.2.b Recorder: The dynamic range has increased from 72 db to 120 db. The use of Sigma Delta technology in 24-bit A/D converter in the FDU has increased the data quality by improving the dynamic range at the ground for each channel before digitizing. The snaking, multi path routing, have given added advantage of recording data across big rivers and express highways thereby reducing gaps in the data.

The data quality is monitored throughout the day. The attributes displayed on workstation in the instrument truck are seismic trace frequency analysis, signal to noise ratio, automatic first break picking. The detailed QC of trace energy and ambient noise value etc. was done in real time. The frequency content of each trace and FK plots were analyzed for every 10th shot.

3. Field Efforts

3.a Online recording of shot and receiver coordinates

Actual coordinates of shots are recorded just after the shot is blasted and recorded. The co-ordinates of the shot points are taken in real time to nullify the positioning error of shots.

Similarly, another two crews were deployed to record the receivers actual positioning during the work. Any deviation from the pre-plot/staked position are recorded on the same day and corrections are made for deviation of receiver position.

3.b Preparation of FTB, NTG, LMO and Brute Stack

FTB and NTG (Fig. 8 & 9) were generated to check starting time of shot and shot coordinates on daily basis. LMO (Fig. 10) was prepared for checking receiver coordinates. Brute stacks (Fig. 11) were generated for all swaths using FPU.

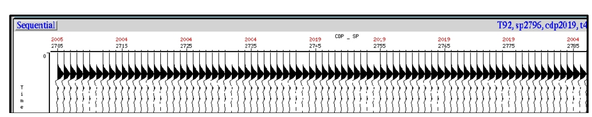


Fig. 8: FTB

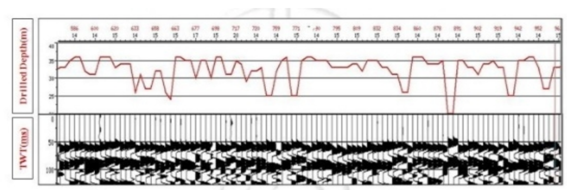


Fig. 9: NTG

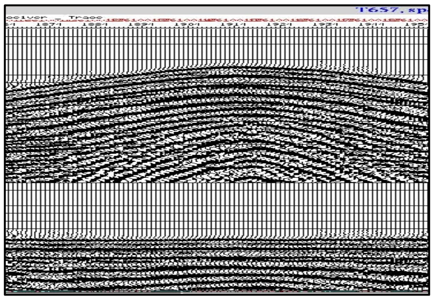


Fig. 10: LMO

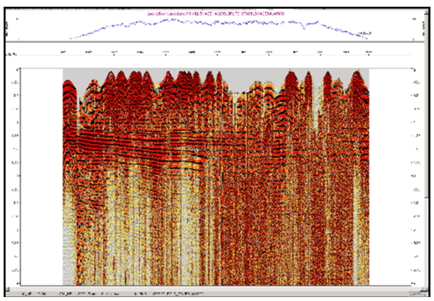


Fig. 11: Brute stack section

3.c Ground Coupling

The tight ground coupling has been ensued in field by regular checking of geophone plantation by seismic field crew on daily basis to obtain high fidelity of ground motion.

3.d Near Surface Modeling

Near Surface models were prepared using Uphole survey data to keep the source in the high velocity medium. Total 11 in-line and 14 cross-line Near Surface Models were prepared over an area of 60 sq. km. A sample near surface inline and cross-line models are given in Fig. 12. Optimum depth for each shot point was determined and maintained in high velocity zone. The same data was used for computation of thickness and velocity of weathered, sub-weathered layers. The thickness of the weathered layer in the operational area varies from 5m to 23m. The velocity in the weathered layer varies from 400m/s to 900m/s and the sub-weathered layer varies from 1400m/s to 2100m/s.
Special care was taken where data quality deteriorates due to change in subsurface lithology. Correlation of litho-sample with raw monitor records and check shots were helpful in improving data quality.

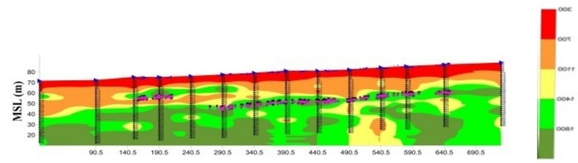


Fig. 12a: Inline Near Surface Model

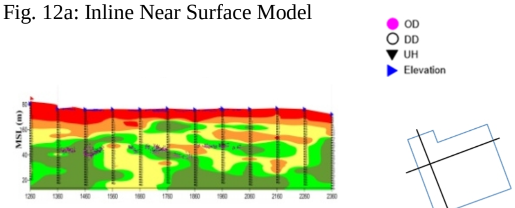


Fig. 12b: Cross line Near Surface Model

3.e Online & Special Recovery

The houses, tube wells, oil/gas pipe lines, highways, railway line, industrial campus, oil companies' installations, dry river beds, ravines (Figs. 13,14) etc. do not allow the regular drilling of shot holes in on land seismic data acquisition work.

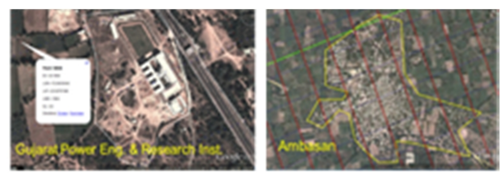


Fig. 13: Obstacles in the area

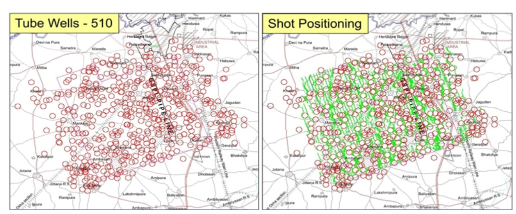


Fig. 14: Tube wells and positioning of shots

In 3D seismic surveys a gap of 30-40 continuous shot holes creates a hole in the subsurface coverage. To avoid these gaps the obstacles were mapped well in advance and recovery shot points were identified and information was given to drilling crew to release recovery shot point along with the regular shots. The improvement in foldage is shown in Fig. 15.
Special recovery was carried out to improve foldage. After executing recovery plan the fold map has increased to 45-50 (Fig. 16).

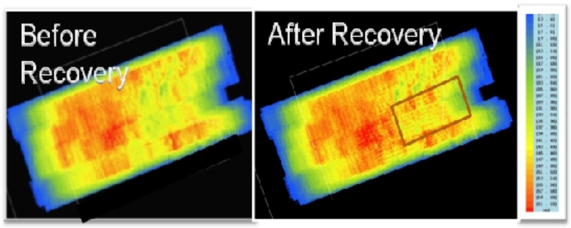


Fig 15: Foldage gain due to recovery

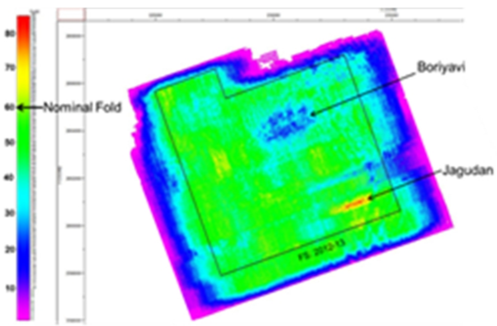
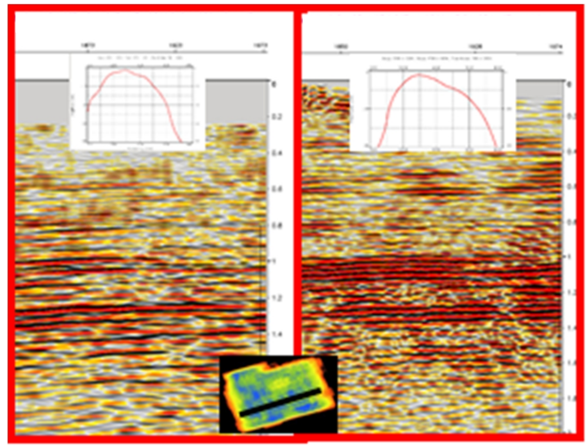


Fig 16: Fold map of the area

3.f SPS checking

Velocity model was built to prepare static correction. Near surface velocity model was smoothed into three layer model using 'SRSURVEY' software and these models were interpolated for entire area. Static correction was applied on the data in FPU and thorough QC was done before sending data to RCC. The statics data was incorporated in SPS.

4: Processing: At RCC efforts were made for ground roll attenuation, De-noising, Velocity picking at close grid interval, Variable dip handling and 3D regularization before migration and high frequency processing. The improvements in data quality with respect to old data is given in Fig. 17.



Old section New section

Fig 17: Improvement in data quality (courtesy RCC, ONGC, Vadodara, India)

Conclusion:

Use of Asymmetrical Split Spread geometry with shooting from both ends, real time recording of shot and receiver coordinates along with the field efforts for ensuring tight coupling and placing of charge in high velocity medium, recovery planning and execution have improved quality of data in Jotana Mewad area.

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