

Value additions in carpet 3D seismic data acquisition in Dabka-Jambusar-Matar area of WON basin, Gujarat

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Summary: Carpet 3D seismic data acquisition in Dabka-Jambusar-Matar area was planned for two field seasons (FS) to bring out a highly resolved images of complex features of subsurface. The value addition in seismic data acquisition is done to improve quality, productivity and mitigate HSE risks.

The value addition in seismic data quality was done at various activities like designing of field parameters, use of multi component digital sensors in place of geophones, recording of 3C upholes in addition to P wave upholes, recording of wide band of frequencies, processing, implementation of rigorous quality control measures, online corrective measures. Higher level of team work and dedication during entire process have yielded good results.

Productivity is increased by identifying and removing bottlenecks in shot hole drilling and lying of ground electronics. The farmer resistance was reduced by counseling and liasoning with local populace.

HSE standard was raised by strictly adhering to QHSE norms of the company. The oil and gas pipe lines present in the area were mapped before drilling of shot holes in the area. CSR activities and eye camp were organized to generate goodwill in the working area.

1. Introduction

In Dabka-Jambusar-Matar area number of producing oil and gas wells are present. The major Oil/Gas fields falls in and around the operational area are Gandhar, Jambusar, Dabka, Matar, Padra and Gajera fields.

The operational area for data acquisition largely covers Jambusar Dabka II to IV ML, Dabka ML & its extensions, Kural ML and Matar ML. Major Gajera fault is lying on the western side of the area and throw of formations along the fault is in the range of 700-2000m.

A carpet 3D survey was planned for two FS in the area to bring out new pools in strati-structural prospects from Miocene to Lower Paleocene for prospectivity of Shallow horizons of Babaguru & Tarakeshwar and deeper horizons at Synrift Olpad.

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 Dabka-Jambusar-Matar area.

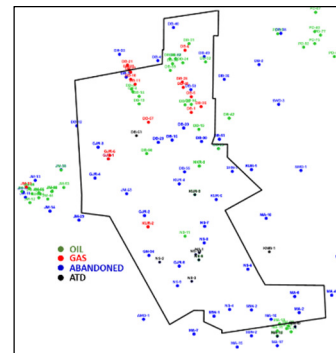


Fig. 1: Dabka-Jambusar-Matar area

The value addition in seismic data acquisition was done in following heads

- Seismic data quality
- Productivity
- Health, safety, and environment

2. Methodology

2.1 Seismic data quality

The value addition has been done on following activities:

1. Geometry design and its evaluation
2. Use of technology
3. Field Efforts
 - a. Multicomponent recording.
 - b. Recording wide band of frequencies.

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- c. Recording of 3C upholes
 - d. Use of Prithivi software for 3D NSM
4. Processing

2.1.1.a Geometry Design and evaluation:

Many acquisition geometries were designed and analyzed for assigned target and objectives using MESA software. The bin size was fixed as 17.5 X 17.5 m. Finally four acquisition geometries, A, B, C and D were selected for detailed comparison (Table 1).

Table 1: 3D geometries for comparison

Geometry	A	B	C	D
G.I / S.I (m)	35 / 35	35 / 35	35 / 35	35 / 35
Rec.Lines	16	16	16	12
Spread Type	SSS	ASS	SSS	SSS
Channels/line	196	80+116	224	252
RLI (m)	280	280	280	280
SLI (m)	245	245	245	245
Rollover	4	4	4	3
Shots /Salvo	32	32	32	24
Fold	112	112	128	108
Far offset (m)	4316	4830	4713	4803

The geometries were evaluated on unique offset fold, azimuthal coverage, percentage of bins falling in the zone of interest (Figs. 2 & 3).

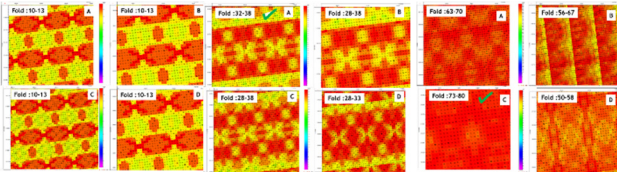


Fig.2: Fold variability for 0-1000 m, 1000-2000 m & 2000-4000 m

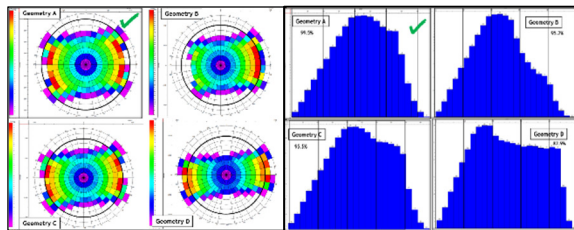


Fig. 3: Rose diagram & percentage values for offset distribution

Symmetrical Split Spread (SSS) with 3136 active channels 16 receiver lines and 4 line swath roll over is effective. Geometry A has consistent unique offset fold variability, better availability of offsets in all directions.

2.1.2 Use of Technology: The available technology was used to mitigate risk and improve quality. The latest Surveying equipment and Data recording instrument were utilized. The Scorpion I/O IV recording unit, Field Processing Units, Open CPU, SURFER, MESA and NORSAR software for designing of field geometry and modeling of complex geological set up had improved quality.

2.1.2.a Surveying: The DGPS (Differential Global Positioning System) gives easting, northing and elevation of the pickets in cm accuracy after applying the Carrier Phase corrections. Google maps and satellite imagery was used to plan the shot and recovery points before moving to field. Shot coordinates were recorded in real time to nullify the positioning error of shots. The receivers which were relocated due to watering in filed or crop cutting were reoccupied on the same day.

2.1.2.b Seismic Data Recording

2.1.2.b.i Accelerometers: SVSM (Standard Vector Seis Module) - accelerometer with MEMS (Micro Electro-Mechanical Systems) technology was used in the operational area. These are lightweight and are capable of recording full seismic wave field. Use of these accelerometers has reduced cost of transportation and has improved data quality.

2.1.2.b.ii Recorder: Geophysical Services of WON Basin have upgraded the recording instruments in last 15 years from DFS V to SN 388 to MDS 16 to 408 UL to Scorpion IV. In A-units the 24-bit Delta-Sigma A/D converter has increased resolution without reducing the range. The channel capacity has increased from 100 channels to 5000 channels for P wave and 15,000 for multicomponent recording. The dynamic range of sensors/ground electronics has increased from 72 db to 130 db. The snaking, multi path routing, handling of hydrophone and SVSM in the same survey has given added advantage of recording data across big rivers, transition zone and express highways.

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2.1.3 Field Efforts

2.1.3.a Multicomponent Recording: Full seismic wave (SH and SV waves along with P waves) was recorded using SVSM. SVSMs were planted in pit of nearly one feet deep pit for good coupling with ground to avoid wind noise.

The approved quality manual - Land and Marine Seismic Data Acquisition (LAMSDA) was followed. Monthly feedback from quality control group was received. Internal audit and Management Review meetings were held every six months. Customer's representative and RCC representatives were involved at all levels of decision making and evaluation of data. Corrective and preventive measures were taken as and when required.

Mode conversion generates S wave from P wave. In fractured medium as S-wave passes through fractures, it splits into two S-waves Fig 4.

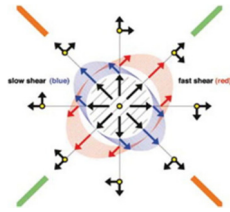


Fig 4: S wave splitting. Black arrows in the centre represent converted wave. Fast and slow S-waves are shown in blue and red colours, respectively.

The blue is fast S-wave, polarized parallel to the direction of fractures. The red is slow S-wave, perpendicular to the fractures plane. Travel time variation of both waves (SV and SH) is recorded at different acquisition azimuths.

For SV section, angle at which the wave shows later arrival time is interpreted to be the direction perpendicular to fractures. On the other hand, angle at which the wave arrives at earlier time is attributed to be the direction of fractures. In the SH section, amplitude drops to zero and phases reversal can be observed at both directions determined on SV section.

2.1.3.b Recording wide band of frequencies: SVSM is deployed as a single-point unit. This eliminates the high frequency attenuation effects of the array. The SVSM technology provided undistorted frequency recording to as low as 2-3 Hz. Combined with the single-point deployment, it recorded 10-15 Hz

broader bandwidth data and ultimately translated to better resolution and better images.

2.1.3.c Recording and plotting of 3C up holes: In the operational area 185 upholes were conducted out of which 17 upholes are 3D-3C. These upholes were conducted at regular interval to estimate the S-wave velocity using first breaks. The orthogonal layout was used. It consisted of two receiver lines L1 and L2 laid perpendicular to each other with uphole at center. Each receiver line had 64 sensors (SVSM) kept at 3 m group interval (Fig 5).

SVSM were oriented such that x components are parallel and Y components are orthogonal to seismic receiver line. Detonators were used as source, at depth from 1-60 m at an interval of 1 m.

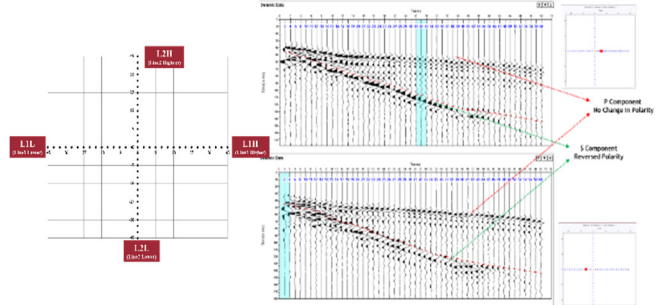


Fig 5: Orthogonal layout

Fig 6: 3C Uphole plot

2.1.3.d Use of Prithvi software for 3D NSM: Prithvi software is developed in-house. It saves time in making uphole plots. All uphole data is fed to Prithvi software which generates 3D NSM.

In 2D near surface models (NSM) 30 to 40 plots are to be analysed to find out the OD for shot points. In 3D one model is to be analysed. It generates slices in between existing upholes. It is helpful in static correction calculation as Inline and Xline velocity matches at crossover points.

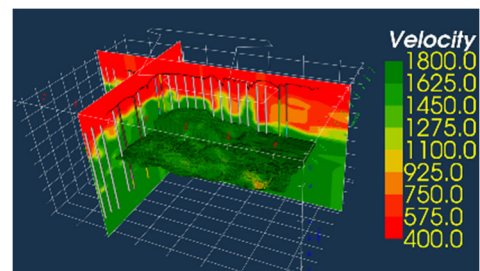


Fig.7:Inline, Xline sections of 3D model, OD surface.

Seismic Data Acquisition

2.1.4: 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. 8 & 9. (Courtesy RCC, WON,ONGC,Vadodara)

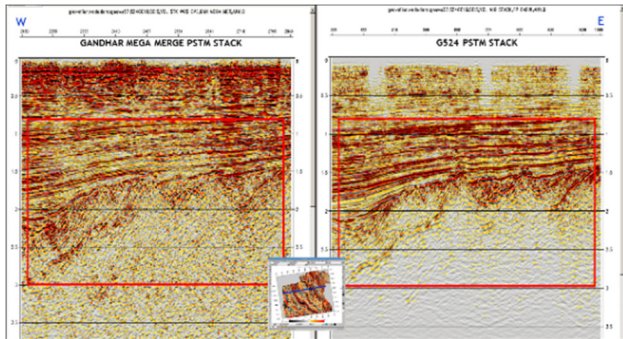


Fig 8: Old section New section

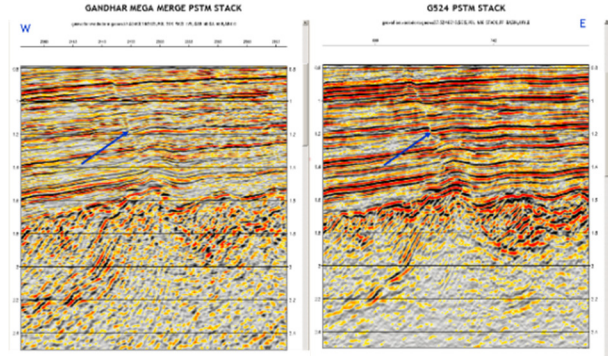


Fig 9: Old section New section

2.2 Productivity: Productivity was increased by adopting following measures

1. All Sarpanch and local officials were informed, counseled about our operation before start of work.
2. Bentonite/cow dunk were used to avoid shot hole collapse.
3. Cables were left in the field in the later part of work.
4. Oil/gas pipe lines were mapped before start of work.
5. Crop compensation cases settled speedily.
6. Workers were motivated by convincing them that they are doing work of national importance.

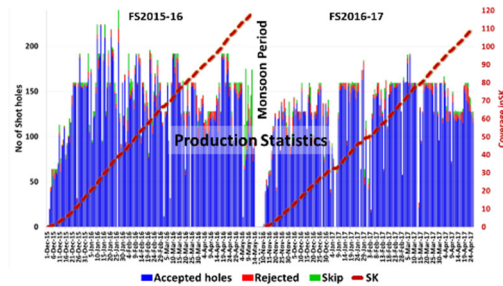


Fig 10: High productivity

Productivity for the two FS was 125 shots/production day which is greater than target (Minimum Guaranteed Hole-MGH) of 100 shots/production day. The work was completed one month ahead of schedule in FS 2015-16 and one and half month before schedule in FS 2016-17.

2.3 Health, safety, and environment

Field parties of WON basin are accredited with ISO 9001:2008 for Quality, OHSAS 18001:2007 for Occupational Health and Safety and ISO 14001:2004 for Environment protection since 2005. Efforts were put to ensure implementation of QHSE norms in true spirit. Party did not get non conformities in both internal audit and surveillance audits. The observations during the audits were compiled. Under OHSAS all targets were achieved

Table 2: Occupational health & safety target & achievement

Target/Objective	Achievement
Use of Explosive.	Accident Free Operations
Prevention of sun stroke	Workers counseling, PPE
PME of employees	100 % PME
Mock Drill / Month	One
Safety Meeting / Month	One
Counseling of workers	Weekly for each Crew

Similarly targets were also achieved under ISO 14001:2004 for Environment protection e.g., emission control of vehicles, noise pollution from generator, tree plantation and maintaining garden in camp.

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The activities and camp lay out of the Party is standardized. A sea change has been brought about in the attitude of party personnel towards health and safety. The journey management, mock fire drill, emergency response plans, disaster management plans have added extra safety measures in all operations. The party did not pollute air, water and soil.

A 10 kw solar power plant was installed in the party. For transporting solar panels special racks in an old bunk house is designed and fabricated. All old tube lights have been replaced with LED lights in phased manner.



Fig 11: Fire mock drill, Safety at work place, tree plantation, eye camp, beautification of camp and solar lights.

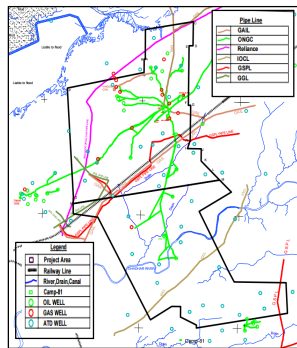


Fig 12: Oil and Gas pipe line in the area

The oil and gas pipe lines were mapped using the pillars and markings on the ground with GPS before the start of production work. A safe distance of 50 m was maintained from pipe line. It has mitigated the

risk of puncturing the pipe lines. Accident free operation was carried out during both years of work.

Conclusion:

The value additions have helped in generating good quality sections which are better than the benchmarked data.

Value addition in seismic data has been done through good geometry design and its evaluation, Use of technology, use of multicomponent recording, recording of 3C upholes, use of innovative approach in processing of data. 3D-3C data has been recorded using multicomponent sensors.

Value addition has been further brought by maintaining high productivity during two field seasons, thus reducing API cycle time.

Accident free operation in industrial area in first year and in crocodile infested area in second year has shown the effectiveness of OHSAS implementation. Generation and use of solar power has added a step towards carbon free environment.

References:

1. A review on multicomponent seismology: A potential seismic application for reservoir characterization. Journal of Advanced Research, Volume 7, Issue 3, May 2016, Pages 515-524, Mohammed Farfour et.al.
2. How to meet the “cheaper, faster, better” challenge by Bruno Deletang, TLE Oct 1999.

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