Advantage of Digital Sensors Over Analog Sensors in Enhancing Seismic Resolution – A Case Study from Cambay Basin

M.K.Jain*, A.K.Sarkar, B.K.Barve, U.K.Chatterjee, S.Panigrahi
ONGC, Vadodara
Jain_mk1@ongc.co.in

Summary

Digital sensors meant for acquiring full wave seismic data has the potential to better image reservoir with broader bandwidth and high resolution over the data with analog sensors. A 2D seismic profile was shot to record data simultaneously with digital and analog sensors in Kadi area of Cambay Basin to make a comparative study of the digital sensors (Vectorseis) over analog sensors (SM-24). All the acquision parameter were kept same to acquire the data so as to have a meaningful analysis (fig.2). The wider bandwidth of signal recorded by digital sensors including the very low frequency signals of the range 1-8 hz, were preserved throughout the processing flow, which helped improving the resolution. To attenuate low frequency shot generated noise, instead of frequency filter, f-k filter was used. Use of an identical processing flow, with carefully preserving the signal bandwidth at every stage of processing, the processed output clearly indicates better resolution in the case of digital sensors over that of analog sensors. The effect is spectacular in the shallower part of the recorded data.

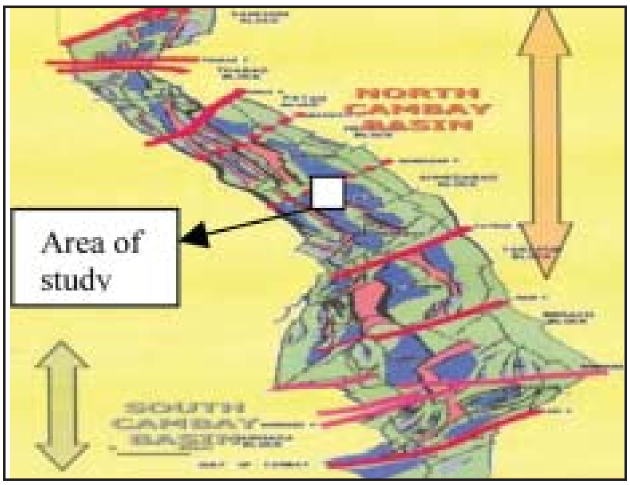

Fig.1: Tectonic map showing area of study

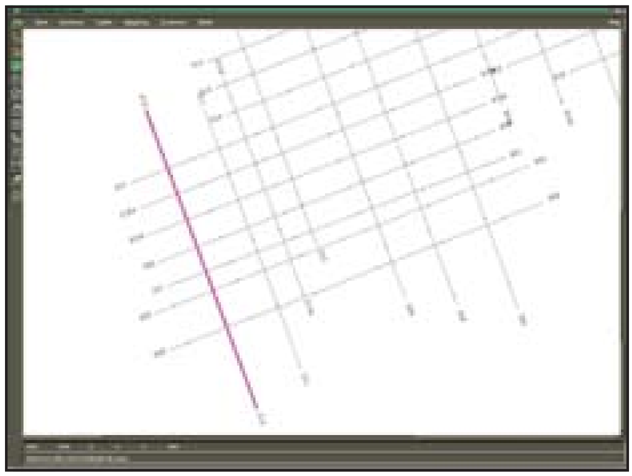

Fig.2 : Location map of the area

Introduction

2D multicomponent data was acquired in Kadi-Linch-Nandasan area, which falls in Mehsana-Ahmedabad tectonic block (fig.1) of Cambay Basin. Cambay Basin is an intracratonic rift Basin with elongated graben running approximately NNW-SSE direction, takes a swing in southern part and aligns approximately in NNE-SSW directions. It is flanked in the NE by the Aravali swell and on the west by Saurashtra craton. The Deccan craton rises towards its eastern and south eastern side.The Basin came into existence during late Jurassic. During the late cretaceous major volcanic eruption activities took place and Deccan trap formed technical basement of the Basin. Subsequently different depositional units came into existence in different depositional environments. The 2D data was acquired with 60fold, 240channels (symmetric split spread), group interval 25m and shot interval 50m.

Presence of hydrocarbon in discrete sand bodies in Linch and Mandhali formations has set an objective to delineate the isolated lenticular sand bodies of the area. As an ongoing effort to improve the spatial and temporal resolution of the seismic data to aid in delineating the discrete sand bodies, recently 2D muticomponent data acquisition in the area was attempted using 3 component digital sensors. Digital sensors are capable of recording wider bandwidth of frequencies that the Earth will return, including critical low

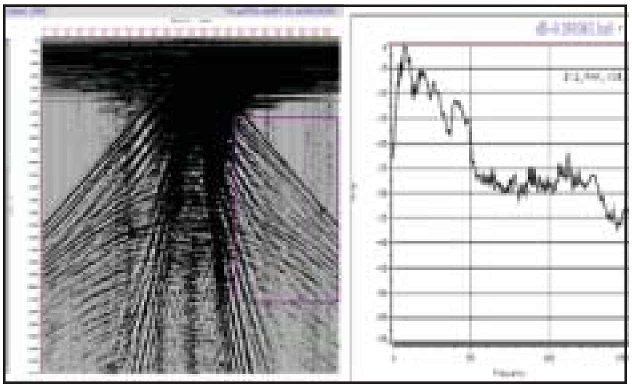

Fig.3 : Raw data of SM-24 sensors with spectrum

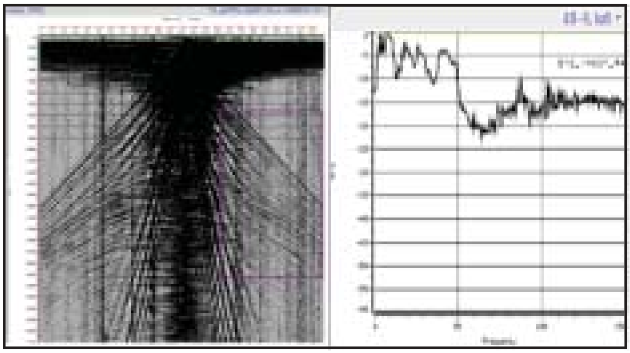

Fig..4 : Raw data of Vectorseis sensors with spectrum

frequencies. There are two advantages that digital point sensors have in recording the full seismic signal bandwidth, first removing intra-array statics and second preserving low frenquencies. The quality of the data acquired with digital sensors appeared to be better than the data acquired with analog sensors earlier. This prompted to shot a profile simultaneously with digital and analog sensors and carryout detailed analysis with respect to bandwidth and resolution. For this purpose a 2D profile was acquired with both the type of sensors with the same acquisition parameters for

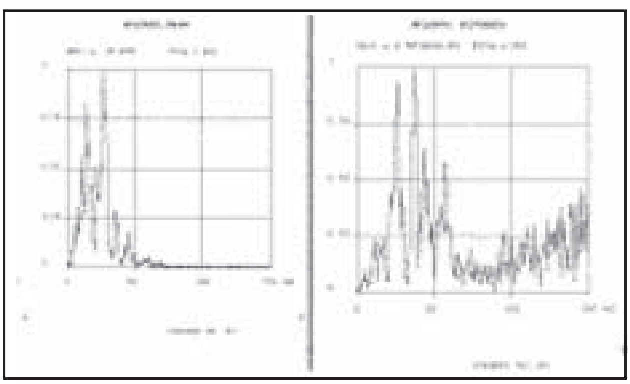

Fig.5: Amplitude spec.

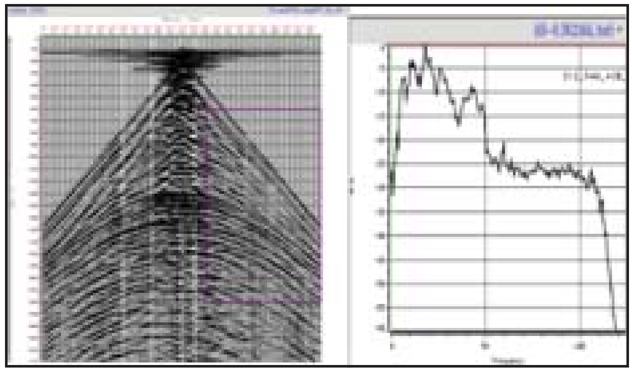

Fig.6 : Raw data of SM-24 after recond

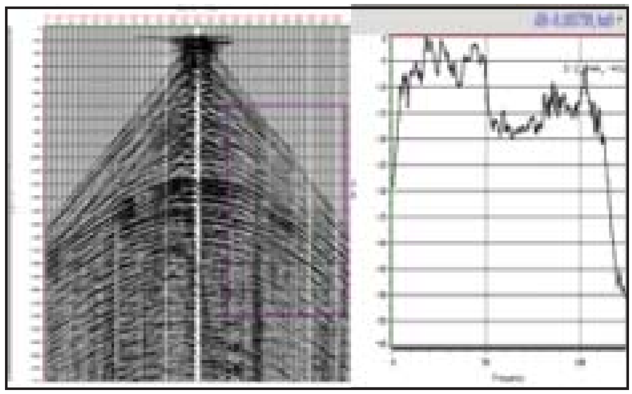

Fig.7 : Raw data of vectorseis after recond.

comparative study of the output, thus generated. The data was processed upto final stack level to study the results.

Data analysis

Fig.3&4 show the raw data quality recorded by analog (SM-24) and digital (Vectorseis) sensors respectively with the corresponding frequency spectrum. The raw data of both the type of sensors are dominated by strong low frequency ground rolls, present mainly in near offset traces. The broad and flat frequency spectrum in the marked zone in the case of Vectorseis sensors shows prence of wide frequency range in comparison of SM-24 sensors in data acquisition stage itself, which will aid improve resolution in the final output. The amplitude spectrum of raw data of Vectorseis also shows the presence of high frequency as compared to that of SM-24 sensors (fig.5). The low frequency component of the seismic signal present in data acquired by Vectorseis is important for resolution, therefore, design of band pass filter for attenuating low frequency ground rolls need attention so as to preserve the low frequency signals in different stages of processing.

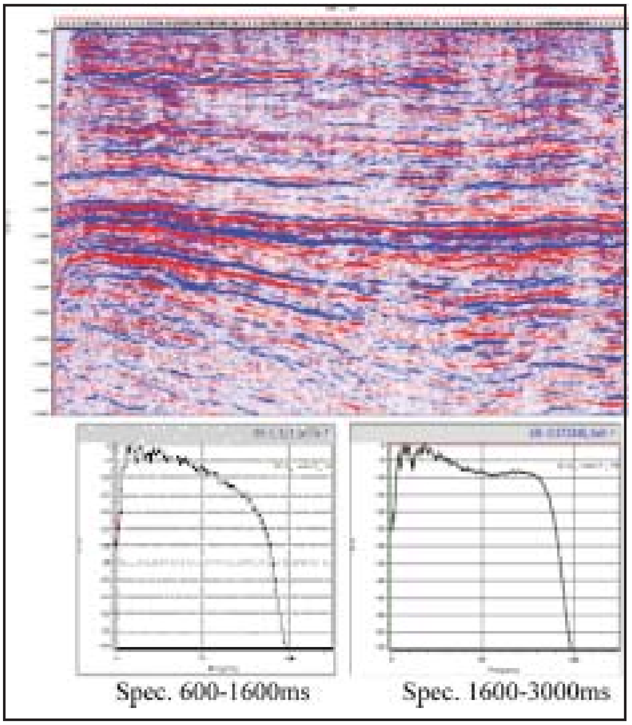

Fig.8: Decon stack of Vectorseis

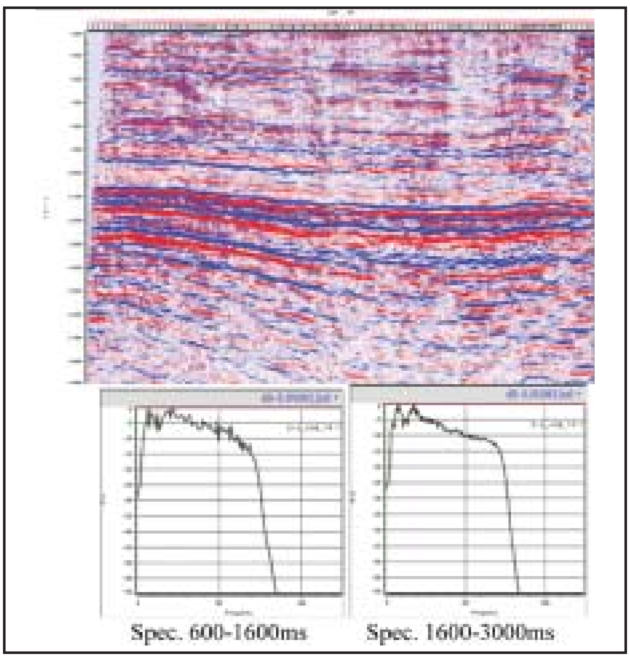

Fig.9: Decon stack of SM-24

Data processing

A conventional processing flow was used to process the data acquired by both the type of sensors. However the key issues, which needed attention in the processing were, S/N ratio and the bandwidth of the data. Digital sensor has very high band width, therefore, the signal present in the data is contaminated with low frequency ground rolls and high frequency random noise. Since the ground rolls present in the data were of the order of 2-10 hz, therefore, to accommodate the signal present in this range of frequencies, use of band pass filter is restricted to the lower end of the spectrum. Exhaustive testing was done to attenuate the random noise present in the data and in designing pre filter for further processing. As the use of band pass filter was restricted, f-k filter in shot domain was used to attenuate the low frequency ground rolls.

Following processing flow was used to process the data.

- Pre filter : 2-4-100-120 hz
- Geometry merging
- F-K filter in shot domain
- Deconvolution : Gap 2ms, Length 160ms, Two window
- Velocity analysis at 500m
- Residual statics 1st pass
- Velocity analysis at 500m
- Residual statics 2nd pass
- Velocity analysis on DMO correct gathers at 500m
- DMO stack
- Random noise attenuation

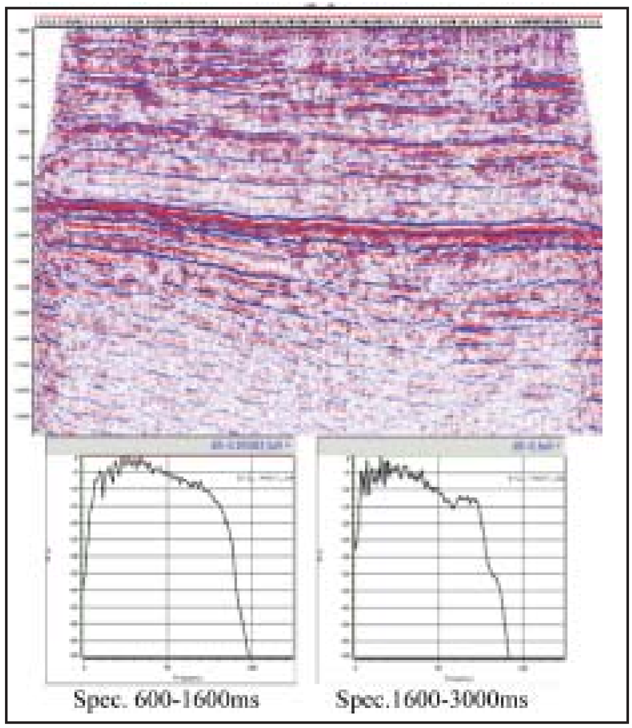

Fig.10 : Final stack of Vectorseis

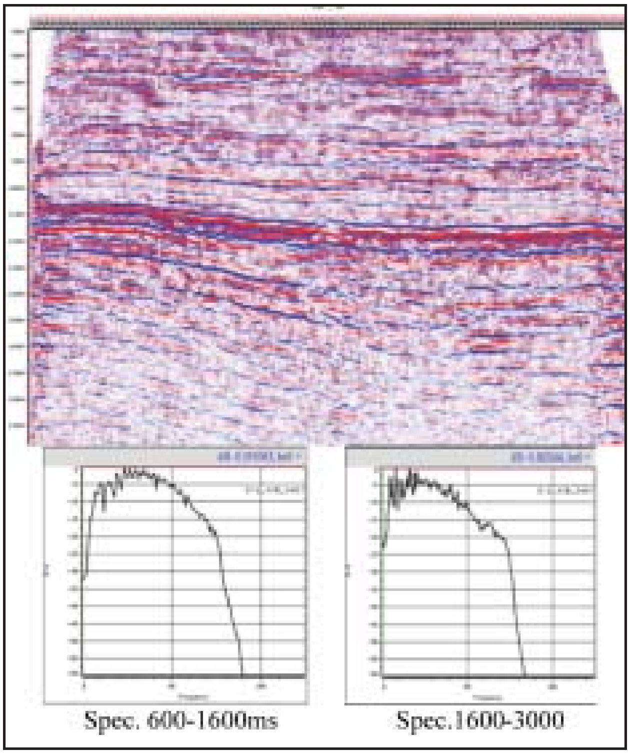

Fig.11 Final stack of SM-24

- Decon after stack : Gap 28ms, Length 160ms, One window
- Time varying filter

Results and discussion

Application of f-k filter in shot domain was able to attenuate low frequency ground rolls effectively while preserving low frequency present in the signal. Fig.6 & 7 show the raw data of both the type of sensors after reconditioning of the data with their frequency spectrum without the application of band pass filter for attenuating the low frequency noise. Stacks after each step was taken to monitor the quality of the two types of output along with their frequency spectrum. Fig. 8 & 9 show the stack after deconvolution of Vectorseis and SM-24 sensors with spectrum in two time zones. Enhancement of band width and resolution can be seen after deconvolution in the case of Vectorseis data over SM-24 sensors data. Final stacks of the profile with their frequency spectrums also show wider band width with better resolution in the data recorded by Vectorseis over SM-24 sensors. The improved resolution is conspicuous in the shallower part (fig. 10 & 11) of the stack section

Conclusion

Raw data of digital sensors(Vectorseis) shows the presence of higher band width over the analog sensors(SM-24) data. The decon stack and final stack in the case of Vectorseis sensors also shows higher band width and better resolution over the SM-24 sensors. Therefore, digital sensors appears to be a better alternative in delivering high quality seismic images with improved resolution, specially in the case of shallower targets for hydrocarbon exploration, that ultimately improve our geological and geophysical understanding and development of oil and gas reservoir.

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The views expressed in this paper are that of the author(s) only and may not necessarily be of ONGC.

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