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3-D seismic data acquisition, with special reference to recovery programme, in Contai area, Bengal Basin, India

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Summary

This paper describes a case history of 3D seismic survey carried out in Contai area of Bengal basin, India during the year 2007 by an ONGC departmental crew, GP-29. The objective of the survey was to image paleo-channels in the depth range from 500m. to 2000m and deep seated strati-structural features occurring in the depth range of 2000m. to 3500m. The survey was done deploying state-of-the-art recording equipment 408UL with a geometry consisting of 1176 active channels, square bin of the dimension 25m. x 25m. and foldage equal to 42. The survey was accompanied with stringent data quality that resulted in good quality of data to the satisfaction of the client.

The value addition in the survey has been the innovative technique related to recovery programme undertaken by the crew to recover the foldage / offset losses in the south-western part of the area resulted due to skip of shots. The skips were inevitable due to presence of cluster of small to big villages. The adopted recovery templates made it possible, with time / cost effective approach, to negotiate the area characterized by low foldage / missing near offsets.

Introduction:

Hydrocarbon exploration efforts in Bengal Basin (onland) have recently taken a new dimension especially in the field of seismic data acquisition following reported gas shows in the well Govindpur-1 at Paleocene level (fig.1&2). The immediate follow up action was to execute 3-D seismic survey in Govindpur area by an in-house crew (GP-39, ONGC, Chennai,) during the field season 2004-05 with the prime objective to chase the gas show and delineate further HC prospects in the area (Gangaiah. A., 2004).

As a further step ahead, it was decided to continue the Govindpur 3D seismic survey southwesterly (fig.1) in order to cover the Contai area during the field season 2006-07 (Roy. A. K., 2007). The survey was carried out by Geophysical Party no.29, ONGC, Chennai during

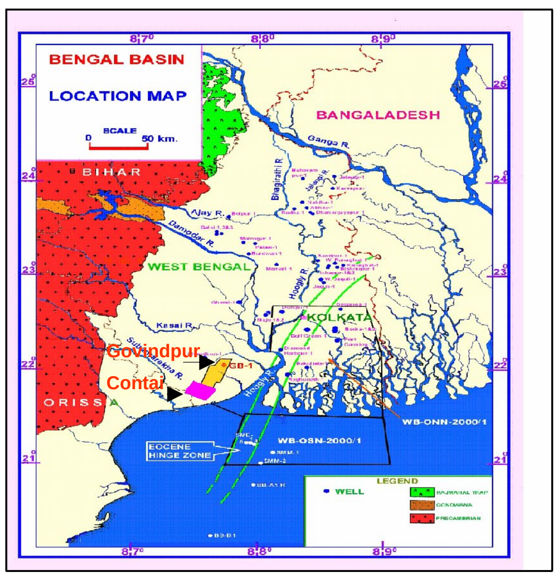

Fig.1: Location map of Bengal Basin showing the area of operation (Courtesy : ONGC, Kolkata)

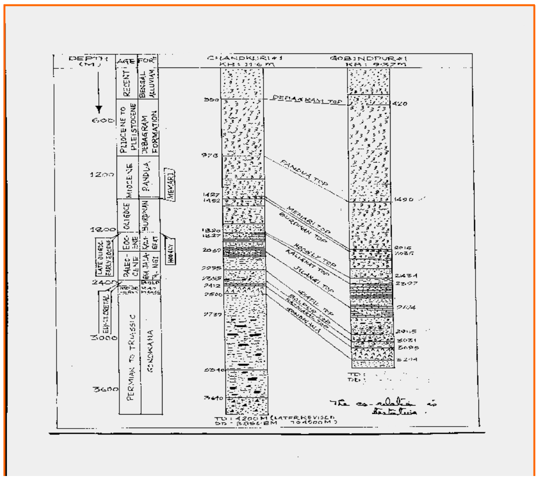

Fig.2: Correlation between the drilled wells Chandkuri-1 and Govindpur-1 (Courtesy : ONGC, Kolkata).

the period Feb'07 to June'07 deploying 408 UL recording instrument with the prime objectives to delineate Plio-Pliestocene channels in the TWT window of 0.5 to 2.0 sec., strati-structural features within Paleocene and Gondwana sediments in the TWT window 2.0 to 3.5 sec. and to confirm anomalies obtained from previous 2D surveys.

Details of the above 3D seismic survey in Contai block is discussed with an emphasis on the special recovery programme to negotiate the foldage / offset loss due to skips of shots in the south- western part of the area because of presence of cluster of villages.

Brief geology of the area and hydrocarbon potential:

The major tectonic blocks of Bengal Basin could be categorized into three elements e.g. Shelf, Eocene Hinge Zone or Slope and Basinal part (fig.1). The Contai area is located in the shelf part of the Bengal basin. The basement, in the shelf part, occurs at depths of about 3.0 to 4.0 Km. and is dissected by horst and graben features over which continental Gondowana sediments were deposited. Gondwana sediments ware underlain by post trappean (Rajmahal trap) sequence, which are dominantly marine in nature.

Based on the drilling results of nearby wells i.e. Govindpur-1, Chandkuri-1 (fig.2) and Govindpur 3D data volume (fig.3), the hydrocarbon potential of Contai area is assessed to be promising. The favourable prospects may be associated with the structural features like Govindpur high and possible accumulation of shallow gas in the Plio-Pliestocene channels.

Method:

The basic 3D acquisition geometry template consisted of 1176 active channels, 42 fold (7 x 6) with square bins (25m. X 25m.). Parameters are tabulated in table-1. The attributes derived from MESA/GEOlAND software, were found to be optimized, in order to image the zone of interest (figs. 4 to 8). The survey was done using explosive source. Sufficient dense grid (1.5 Km.) of uphole data was observed to have good control on shot hole depths.

Special care was taken to plant geophone group in a small pit to minimize effects of wind. Swaths were shot in a "snake pattern". The first swath (SW-01) was covered from higher to lower shot line direction and once the end of the swath was reached the next swath i.e. SW-02 was covered from lower to higher shot line direction, and so on, till the last swath was reached. This practice was adopted to minimize time taken in shifting of equipment.

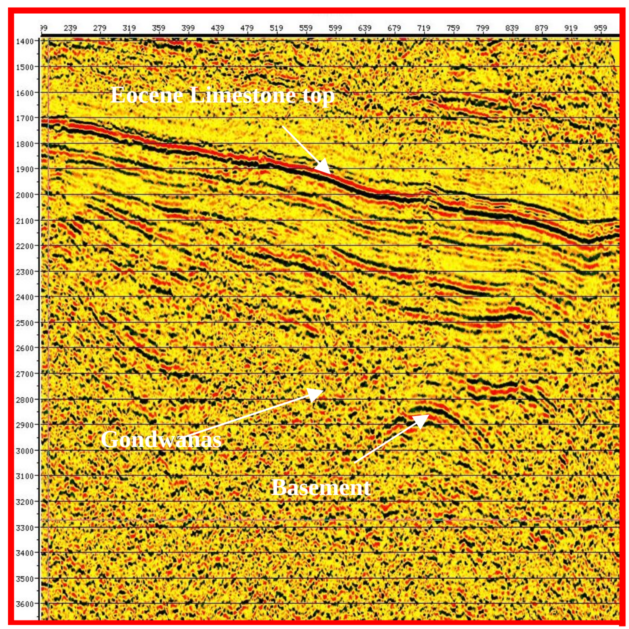

Fig.3: Representative In-line section from Govindpur 3D data volume. Chandkuri-1 and Govindpur-1.

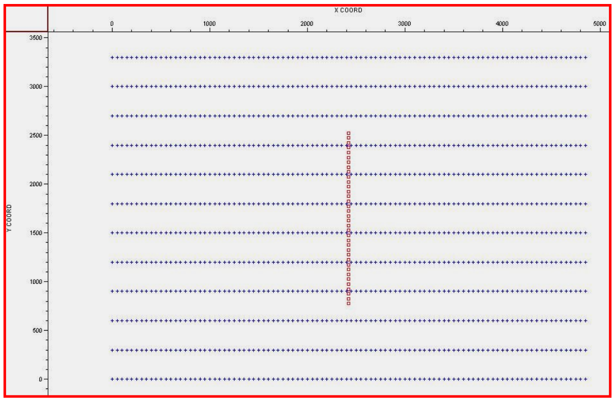

Fig. 4: Unit template geometry.

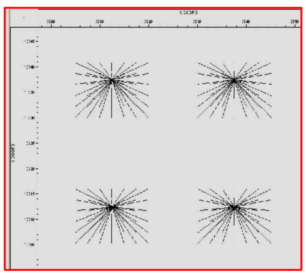

Fig.5:Azimuth distribution

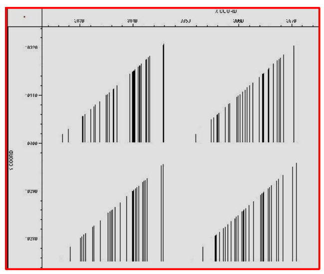

Fig.6:Offset distribution

Table-I: Attributes of the unit template

Parameters	Description / Values	
Type of geometry	Sym. Orthogonal split spread	
No. of Receiver lines	12	
Active channels per line	98	
Total no. of active channels	1176	
Receiver line interval	300	
Shot interval	50	
Shot line interval	350	
Bin Size	25m. x 25m.	
No. of shots per shot line	36	
Cross line Swath roll	6 line	
Fold (Inline x Cross line)	7 x 6	
Nominal fold	42	
Minimum offset (m)	35	
Max. min. offset (m)	573	
Max. offset	3511	
Source density (Shots /Sq. Km.)	57.143	
Aspect ratio	0.386	
Source location area (Sq. Km)	249	
Total no. of required shots	14,223	
Abs. fold (2500 - 3500m.)	3-11	
Unique fold (2500 -3500m.)	3-9	
Offset vs.Azimuth (Rose diagram)	360 deg. up to 3.0 km.	
Offset vs. % of traces	0 - 500m	4.48
	500 - 1000m.	13.44
	1000 - 1500m.	20.66
	1500 - 2000m.	24.74
	2000 - 2500m.	25.18
	2500 - 3000m.	9.83
	3000 - 3500m.	1.67

Integrated analysis of near surface velocity, lithology and trace amplitudes were studied in order to arrive at the optimized shot hole depths. Near surface models along the in-line/ cross-line directions depict that the lateral variation in the near surface velocities was smooth and not abrupt. Charge size of 3.5 Kg. was found to be optimal in this area based on experimental work. As the area was almost free of ground roll, forming of geophone

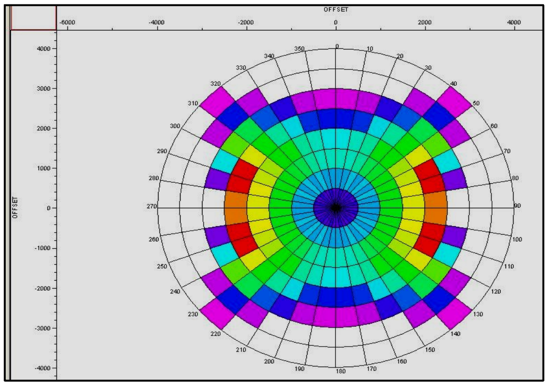

Fig. 7: Azimuth distribution (rose diagram)

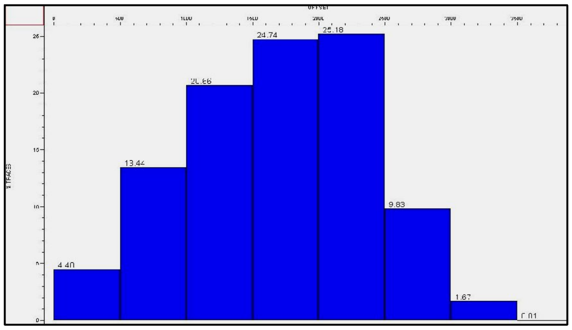

Fig. 8: Offset vs. % of trace histogram

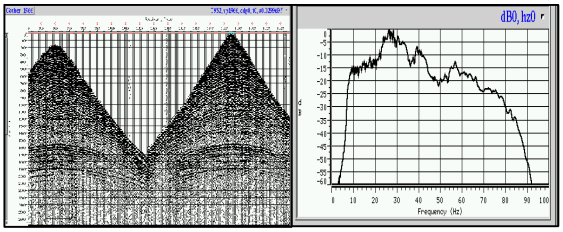

Fig. 9: Raw data monitor record with freq. spectrum.

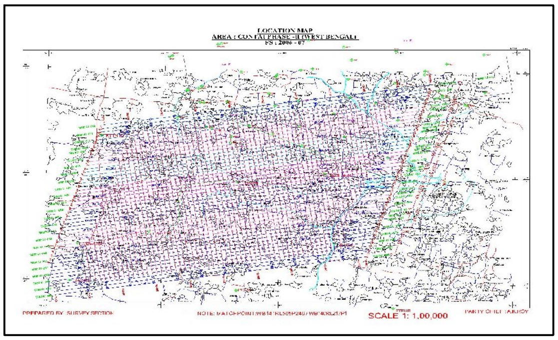

Fig.10: Logistics prevailing in the area (mainly, villages, paddy fields, sugar cane fields, etc.)

array was not warranted. Therefore, recording was done using geophone group consisting of 12 elements bunched together and connected in series.

The entire full fold area and total no. of theoretical shots were estimated to be 200 Sq. Km. and 14,300, respectively. A total no. of seven swaths was required to cover the entire area. The southernmost swath i.e. swath no. 01 was taken up first for acquisition and was continued northward one after another.

Quality Control:

The entire survey was done with active consultation with the quality control team engaged by the client. Field Processing Unit (FPU) / GEOLAND were extensively used for routine monitoring of data quality in the field.

Sample monitor along with frequency spectrum shown in fig.9, reveals frequency content of the raw data is lying in the range of 20 to 40 Hz. An in-line section pertaining to swath-03 (fig. 23) shows the presence of strong events up to 3.0 sec. The structural high and associated normal faults in the right side of the section have clear cut appearances.

Recovery programme:

The southwestern part of the area consisted of densely located villages (fig.10) due to which appreciable number of shots (about 420) could not be taken. The skips resulted in reduction of fold from 42 (fig.11) to 25 (fig.12) The effect was directly seen on the stacked data. However, suitable recovery programme was designed and executed by the crew to compensate for the above foldage loss.

Three separate recovery templates e.g. T-1, T-2 and T-3 were designed as shown in fig.13 for recovering the lost foldage and also the offsets to the extent possible. The parameters for individual recovery templates are described in table-II. In all the three recovery templates, receiver and shots were placed orthogonally, but perpendicular to the orientation of the same in regular swaths.

The approach was to recover the entire low fold zone with minimum no. of shots and receivers to make it cost as well as time effective.

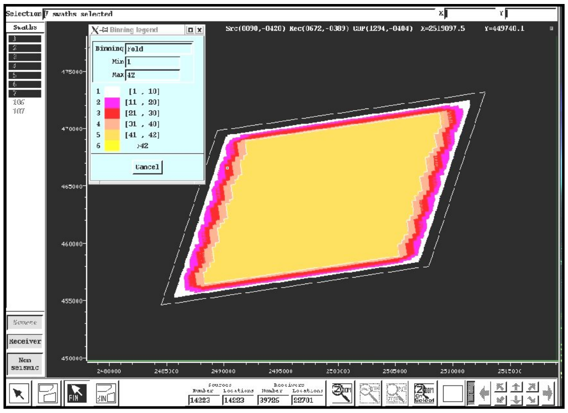

Fig. 11: Theoretical fold distribution (42 fold)

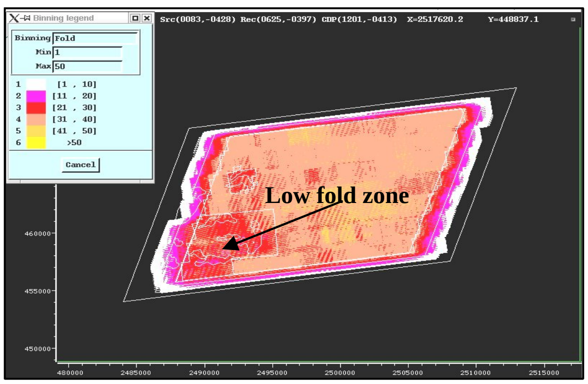

Fig.12: Post acquisition fold distribution before recovery

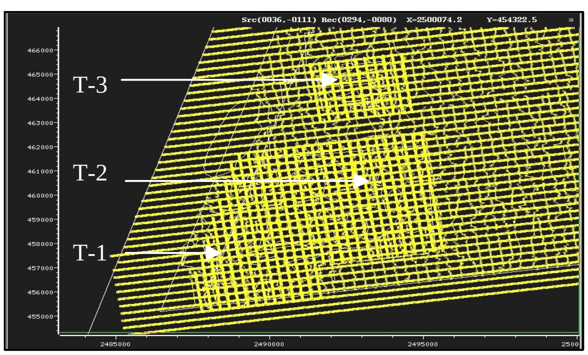

Fig.13: Shot-Receiver layout with recovery templates T-1, T-2 & T-3.

Table-II: Parameters of the recovery template

Parameters	Template -01 (Swath-08)	Template -02 (Swath-09)	Template -03 (Swath-10)
Receiver Geometry			
No. of Receiver lines	14	15	11
Orientation of receiver lines	Along cross-line direction	Along cross-line direction	Along cross-line direction
No. of receivers per line	Varying (33 to 126)	98	49
Total no. of active channels	1412	1078	539
Group interval (m)	50	50	50
Line interval (m.)	350	350	350
Receiver spread	Fixed (Patch)	Fixed (Patch)	Fixed (Patch)
Source Geometry			
No. of shot lines	07	06	08
Orientation of shot lines	Along in-line direction	Along in-line direction	Along in-line direction
No. of shots per line	Varying (35 to 88)	Varying (60 to 92)	Varying (5 to 32)
Total no. of shots in template	432	479	126
Shot interval (m)	50	50	50
Line interval (m)	1000	1000	1000

The improvement in terms of foldage, offsets and azimuth distribution are demonstrated in the figures 14 to 22, focussing the entire zone of low foldage and also for a particular selected bin defined by the CDP no. 309 and In-line no. 133. The fold and offset values corresponding to the bin (309,133) are found to be 19 and 1094 - 2812m., respectively. Whereas, after the recovery the above values for the same bin are found to be 63 and 1007 - 5413m. respectively. Additional azimuth values are also evident in the spider diagrams after recovery. The histograms (fig. 21 & 22) showing the distribution of different ranges of fold values also confirm the success of the recovery programme.

The overall quality of brute stacked data of swath-03, which was maximum affected by the skips, has also improved to a good extent after application of the recovery program as far as reflection strength & continuity were concerned (fig.24 & 25).

The acquired data volume is under final processing in computer center.

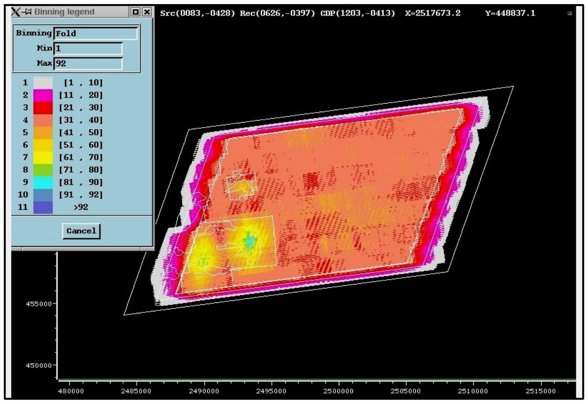

Fig.14: Final fold distribution after recovery

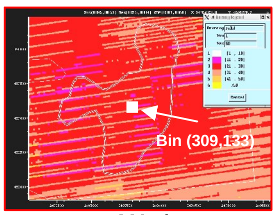

Fig. 15: Fold before recovery

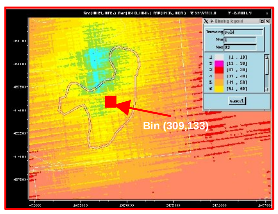

Fig. 16: Fold after recovery

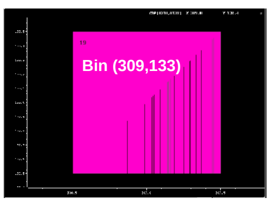

Fig. 17: Fold before recovery

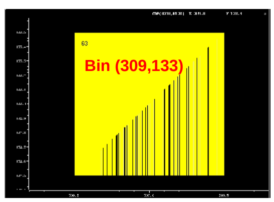

Fig. 18: Fold after recovery

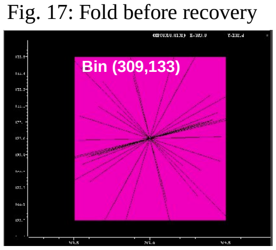

Fig. 19:Azimuth distribution before recovery in a bin (309,133)

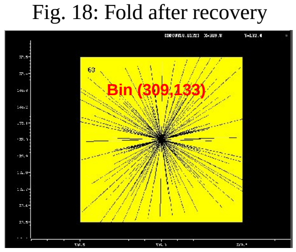

Fig. 20: Azimuth distribution after recovery in a bin (309,133)

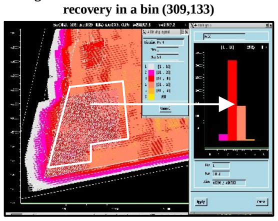

Fig.21: Histogram showing fold distribution vis-à- vis no. of bins within the selected area of low fold before recovery.

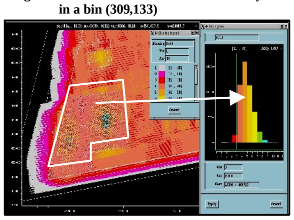

Fig.22: Histogram showing fold distribution vis-à-vis no. of bins within the selected area of low fold after recovery.

Result and Conclusion:

1. The acquisition of 3D seismic data in Contai area could be completed successfully to the satisfaction of the client and without any cost / time overrun.

2. The application of the special recovery programme, thereby, compensating for the lost foldage / offset / azimuth will definitely add value to the final processed data volume.

Reference:

1. Gangaiah. A., "Activity Report on 3D Seismic Survey in Govindpur area, Bengal Basin, Inv. No. M-140, 2004-05 (ONGC, Un-published report).

2. Roy. A. K., "Project Report on 3D Seismic Survey in Contai area, Bengal Basin, Inv. No. M-141, 2006-07 (ONGC, Un-published report).

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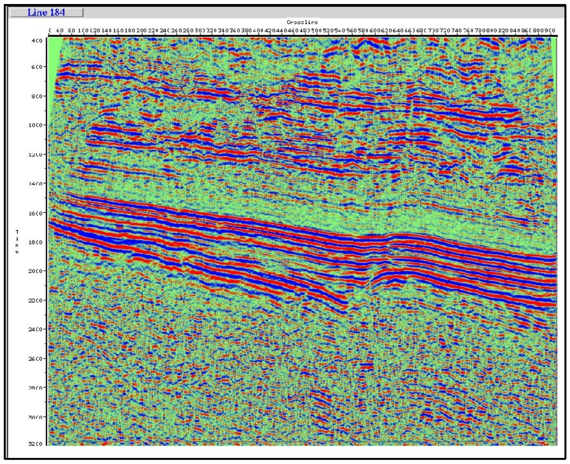

Fig. 23: In-line 184 (SW-03) – Brute Stack

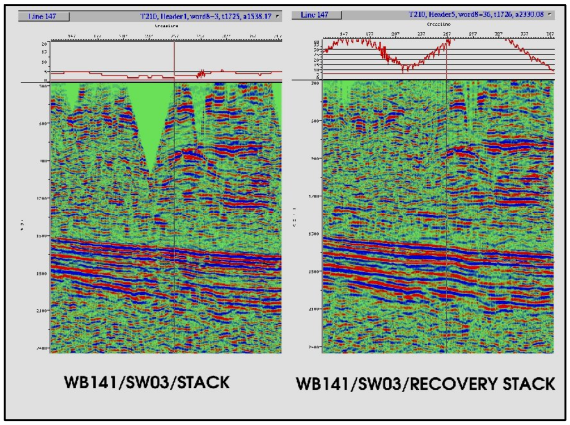

Fig. 24: In-Line 147 (part) of SW-03 before and after recovery

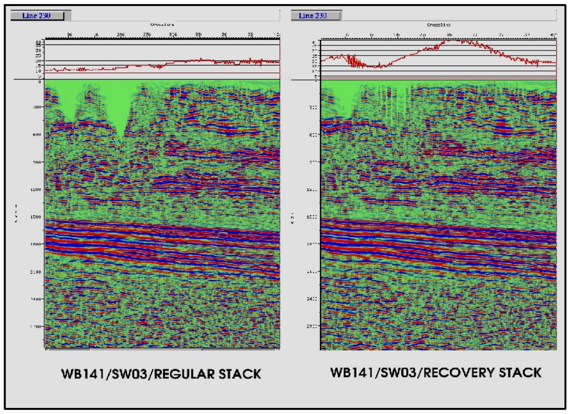

Fig. 25: In-Line-230 (part) of SW-03 before and after recovery