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Enhanced imaging through 3D volumetric refraction static in Rajasthan area: a case study.

B N Roy*, S S Singh, Randeep Guha , K K Sinha, and U S D Pandey, *ONGC, Vadodara.*

Summary

While processing 3D vibroseis data, acquired in the sand dune area of Western Rajasthan (the study area), it has been observed that gathers are not aligned properly even after application of field statics. The stack outputs gave rise to only patchy reflections in the zone of interest as well as at shallower and deeper level. The field static calculations are based on Shallow Refraction data.

To overcome this problem, first break refraction picking on 3D vibroseis data are utilized to estimate near –surface model. First breaks are picked swath wise on 3D data and near surface model computed to calculate static. But this method suffered from the fact that different static values were observed for common shots / receivers in adjoining swaths. A method was thought of by employing entire 3D data volume as a single input to build near surface model. The results so obtained are discussed in this paper. The stack outputs showed remarkable improvements in subsequent processing stages which are also shown and compared with outputs derived from field static.

Introduction

It is very important to accurately calculate the static at the time of processing of land data .This improves quality in the subsequent stages which in turn impacts the integrity, quality and resolution of the imaged section. The situation becomes more complicated if the survey area (Fig 1) is overlain by irregular topography such as sand dunes of varying heights. Hence there is a need to remove the effect of rapid velocity changes in the near surface specially weathering layer. Correct estimation of static due to the presence of weathering zones, sand dunes in this case, is one of the main challenges in data processing and remained the critical issue over the years.

The study area is in desert and no up-hole data are available due to non availability of water near by. Drilling is also difficult because of loose formation due to presence of sand dunes of varying height. Shallow refraction surveys are being conducted to estimate near surface thickness and velocity along with 3D vibroseis data. An attempt is made to estimate near surface features arising out in steeply dipping sand dune area with elevation variation between 60m and 120m (Fig 2).The first break information as obtained in the 3D Vibroseis data conducted in the study area, is subjected to Generalized Linear Inversion program from M/s Hampson Russell, for calculating the static. The results are encouraging which will be seen in the subsequent stages of discussion.

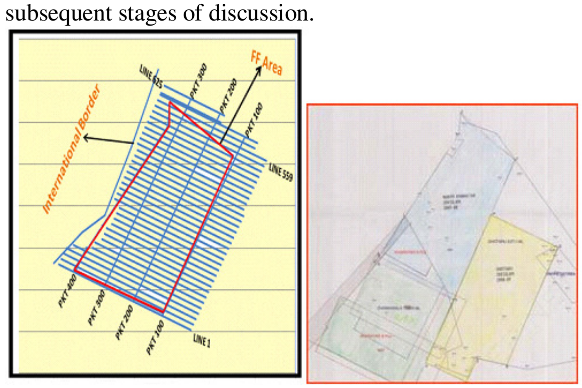


Fig 1 Map showing study & adjoining area

bhupenr2000@yahoo.com

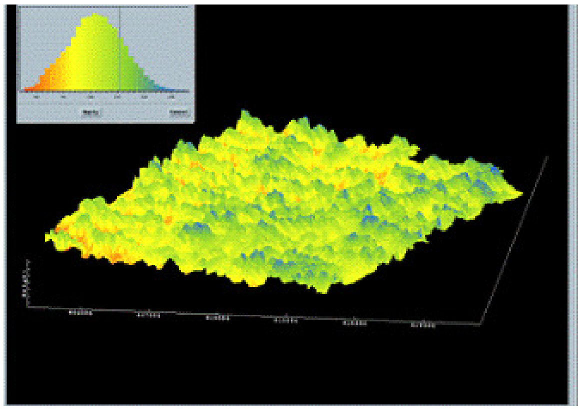


Fig 2. Elevation profile of study area

Acquisition Parameters	
Type of Spread	Symmetric Split Spread
No. of Channels	144 per receiver line
No. of receiver lines	5
Receiver line interval	240m
Fold	45
Group interval	40 m
Short interval	80 m
Record Length	5 sec
Sampling Interval	2 ms
Bin Size	20 m x 40 m
Source Parameters	
No. of Vibrators per VP	4
Type of Sweep	Non-Linear of varying sweep
Sweep length	12 s
Taper length	400 ms
Drive Force	70%

Processing Parameters	
Format Converson	SEGD to CGG
Geometry Merging / Binning	Header Up-dation + Binning
Geometrical Spreading Correction	Time based Recovery (t ** 1.8)
Minimum Phase Conversion	Klauder wavelet extracted from seismic
Pre-Filter	8 -80 Hz
Surface consistent amplitude correction	Amplitude Based Auto Editing
Dephasing filter with the instrument	Applied SN388(Analog)
Surface Consistent Deconvolution before Stack	Two Window 200 – 1900ms 1700 -4500 ms PD 8 ms 12 ms O.L 240 ms White Noise (%) 0.5
Velocity Analysis i	500 m x 500 m
3D Residual Statics i	200 – 2400 ms
Velocity Analysis ii	500 m x 500 m
3D Residual Statics	200 – 2400 ms
Velocity Analysis iii	500 m x 500 m
RMS Velocity Analysis	500m x 500m
PSTM	Aperture 4520m x 4560 m at 2000 ms
RNA	F-XY Domain
Decon After Stack	Two Window 200-2100 ms 1800 – 5000 ms 24 ms 28 ms O.L 200 msWhite Noise (%) 0.5
Final PSTM Stack	

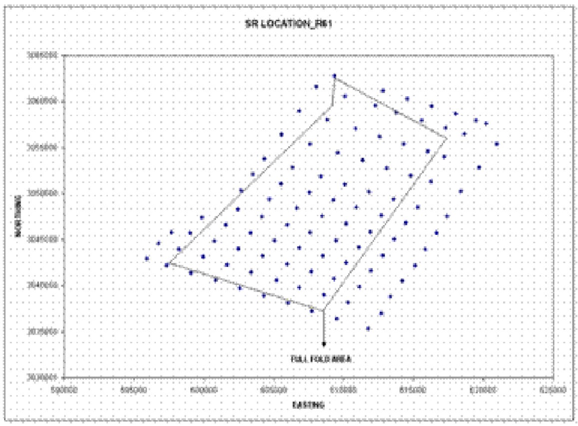


Fig 3. Location Map of Shallow Refraction Survey

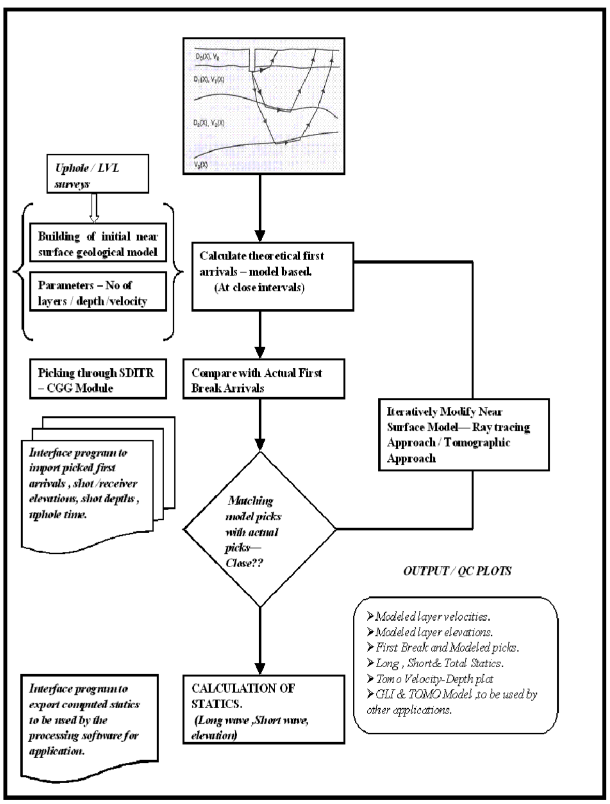


Fig 4. 3D-Refraction Statics Workflow

Conventional practice

Simplified Flow chart for static estimation is shown in Fig 4.

a) First break picks in swath wise mode (Fig 5). Program developed to integrate Geometry Information with GLI3D.

b) CGG tool SDITR of Geocluster introduced for first break picking. Program developed in house to integrate with GLI3D.

c) Modeling / Inversion done in swath wise mode also. Control point guideline taken from SR survey (Fig 3).

d) Statics computed in swath wise mode atoverlapping receivers.

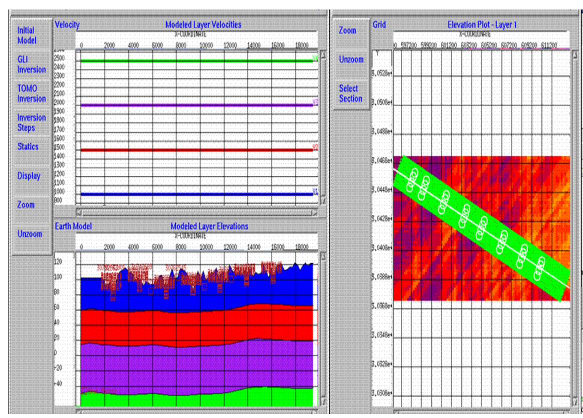


Fig 5. Modeling process – Swath Wise Mode

Limitations

a) Found to be cumbersome & tedious.
b) Repetitive modeling across all swaths in survey area, leading to inconsistent layer attributes i.e. velocity, intercept and thickness.
c) Individual computation of source / receiver statics leading to inconsistent results in overlapping zones.

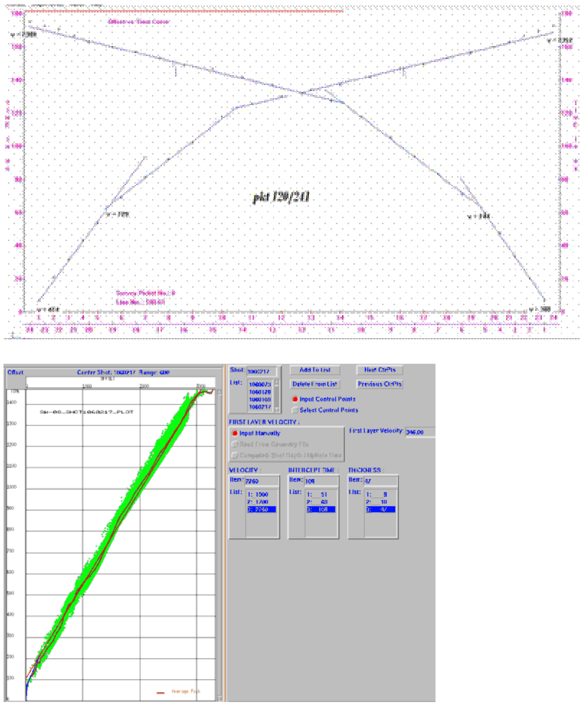


Fig 6. Estimation of layer thickness & velocity from Shallow Refraction survey and First Break pick based Inversion Model

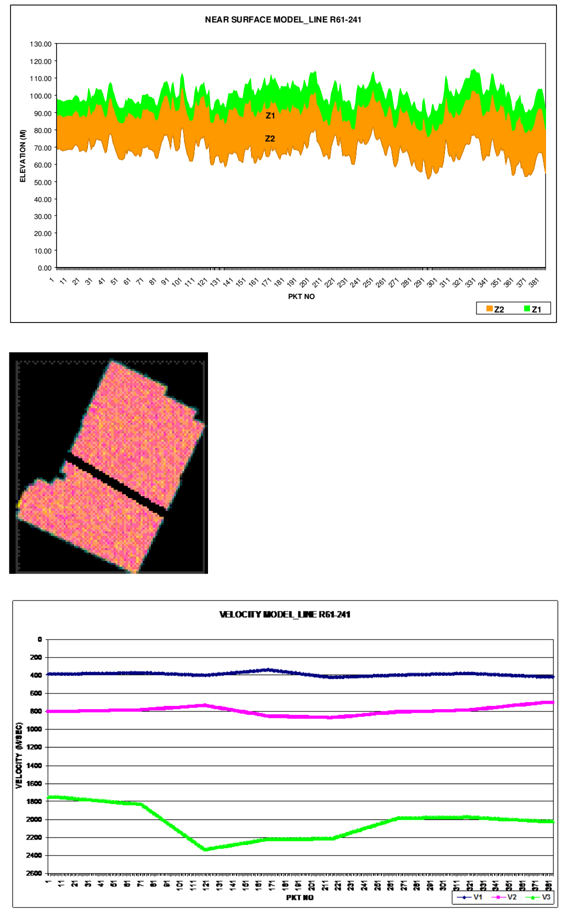


Fig 7 Depth and Velocity model derived from Shallow Refraction data and corresponding location in 3D volume.

Observations on Shallow Refraction (SR) data

Field statics based on SR data when applied to 3D vibroseis data appears to be inadequate to align the reflections as seen in the gathers. Whereas, corresponding gathers derived through first breaks are aligned. Comparison between the two is shown in Fig 8.

The depth model profile from SR data (Fig 7) depicts two layers model whereas a third layer is considerable thickness is inferred from the inverted model (Fig 9). This thickness and the difference in velocity, is instrumental in obtaining better static solution than that obtained from SR data alone.

The velocity & thickness parameters derived from SR data and Refraction model are tabulated below for comparison.

Model	Layer Thickness (m)			Layer velocity (m/s)				Remarks
	Z1	Z2	Z3	V0	V1	V2	V3	
SR	7	24	---	388(414)	744(729)	2309 (2352)	--	Crossover values in ( ).
First Break based	9	10	47	346	1000	1700	2260	V0 value has been taken from SR data for estimating the model

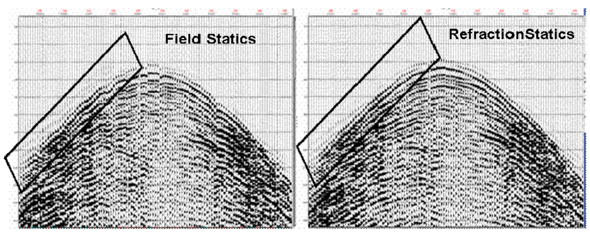


Fig 8. Shot Gathers

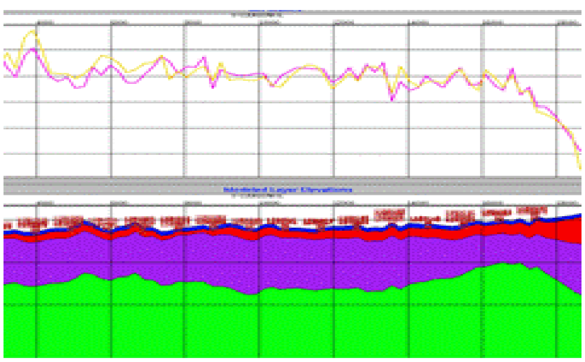


Fig 9. Inverted model through first breaks

Discussion:

Acquisition and Processing parameters are shown in Table 1 and Table 2 respectively.

While preparing the near surface model based on first break picks computed swath wise, few critical issues were noted:

i) Statics shift was observed in overlapping zone
ii) Statics could not be harmonized for common receivers for adjoining swaths.
iii) Travel time inversion had to be repeated for individual swaths to make the best fit model resulting in inconsistent modeling parameters across swaths.

Though the gathers were refined & improved after model based statics application (Fig 10) , static shift is noticed in the overlapping zone as shown in Fig 11. Further, static mismatch in adjoining swaths (Sw2 , Sw3 & Sw4) at Brute Stack as well as at Residual Stack stage are seen in Fig 12 and Fig 13a. The Final Residual Stack is shown in Fig 13b after necessary correction.

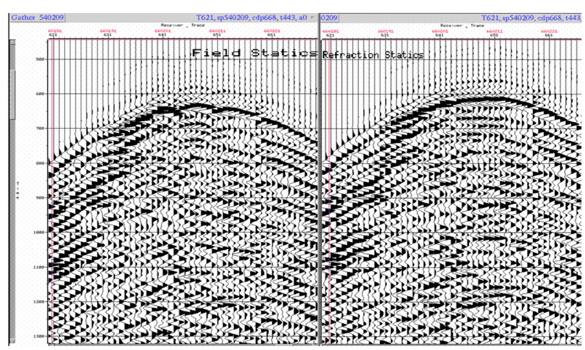


Fig 10 Shot Gathers Field Statics vs Refraction Statics

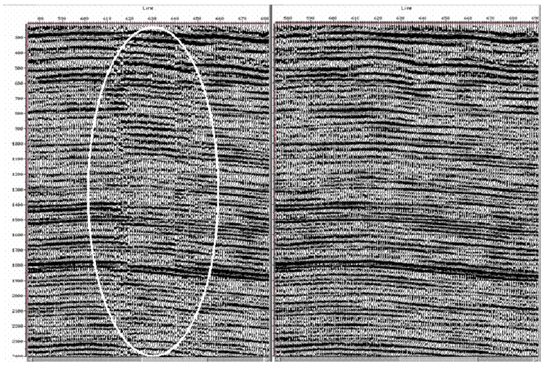
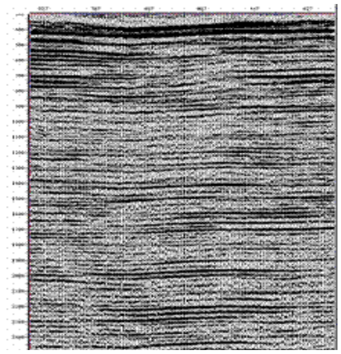


Fig 11 Residual Stack XLine 1



b) Residual Stack after correction

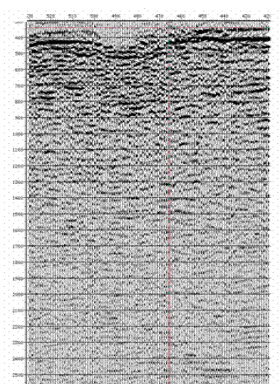


Fig 12 Brute Stack XLine 2

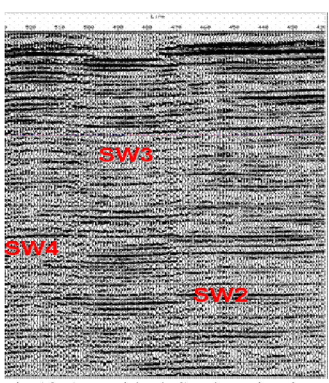


Fig 13 a) Residual Stack XLine 2 static shift is observed in sw3

Conceived Methodology (Volume based)

A methodology was re-engineered to incorporate modeling / travel time inversion in a volumetric mode, the results are shown in Fig 14a and 14b. The job sequences designed taking care of uniqueness of overlapping receivers as per geometry information by incorporating swath identifiers.

i) Developed Program to sum the first break picks in GLI3D geometry format and Control points as a single Volume.
ii) Statics computed in volumetric mode. Harmonization of receiver statics taken care in the algorithm .
iii) Script developed in house to convert GLI3D statics to CGG format**.**

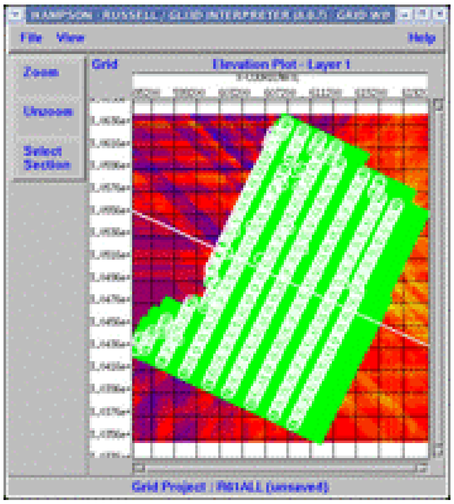


Fig 14 a) 3D volume with control points marked in white circles

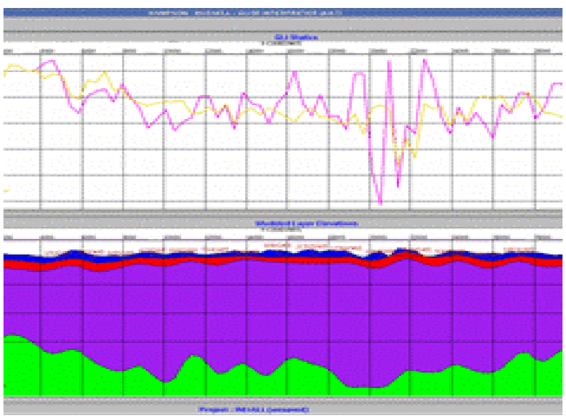


Fig 14 b) Corresponding inverted model along inline of control points

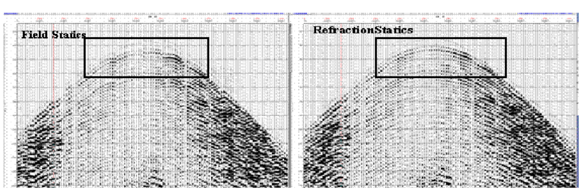


Fig 15 Decon gathers with Field statics vs Refraction statics

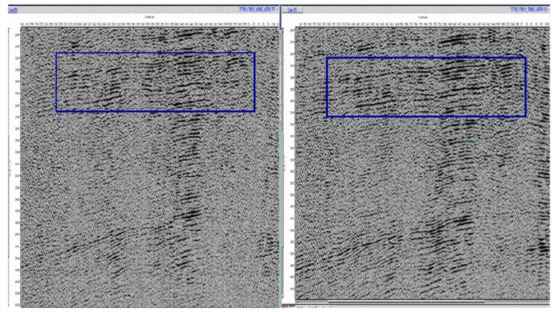


Fig 16 Brute Stack with Field statics vs Ref statics

Results :

The aim of 3D Vibroseis survey was to improve the clarity of faults as well as delineation of small stratigraphic & structural features within Lower Goru and Upper Pariwar formation of Tertiary and Cretaceous age respectively.

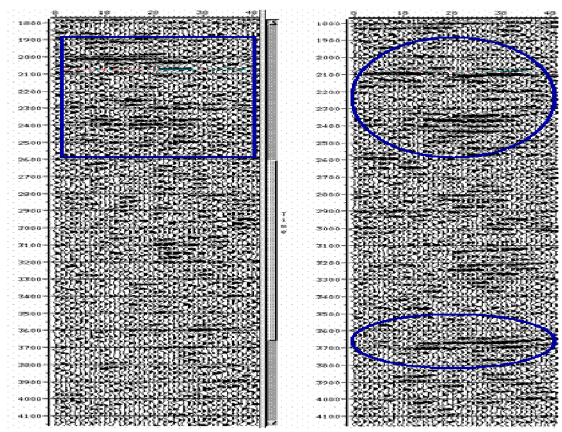


Fig 17 a) Brute Stack X line 1 Field Statics vs Refraction statics

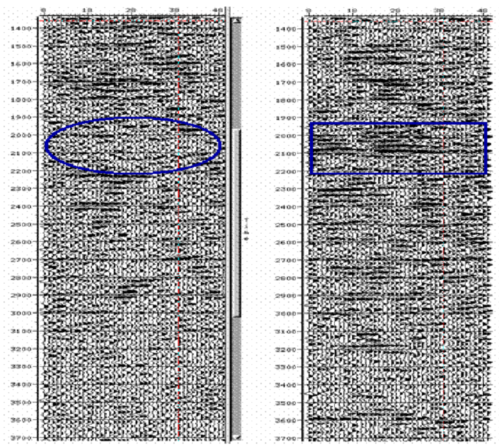


Fig 17 b) Brute Stack X line 2 Field Statics vs Refraction statics

New statics derived from volume based 3D refraction method were applied on the raw vibrosies data and the corresponding Decon gathers are shown in Fig 15 as above. The alignment of each trace is seen in the Decon gathers when compared with field derived statics. The data are further enhanced in Brute Stack level as displayed in Fig 16 and Fig 17 a) & 17 b).

Final PSTM outputs are shown in fig 18 & 19.The delineations of fault pattern are achieved at all levels as well as the mapping of reflectors at Lower Goru and Upper Pariwar formations are also brought out .Finally a close comparison of 2D line with reconstructed lines from 3D data set as shown in fig 20 & 21 clearly demonstrates the improvement in the image quality. (The Acquisition parameters of 2D data are: Group Interval and Source interval 50m ,Fold 48 ,Vibrator source , Asymmetric Split-Spread, Sweep length 16 s , No of Vibrators 4 .)

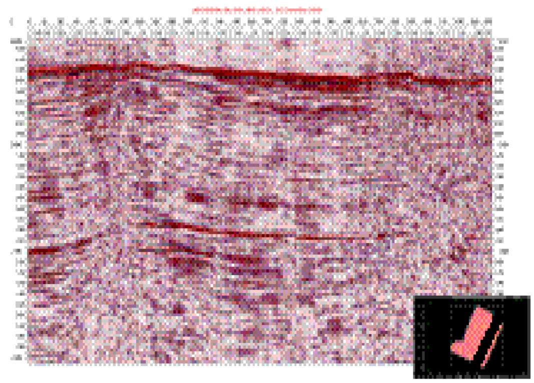


Fig 18 PSTM STACK XLine 1

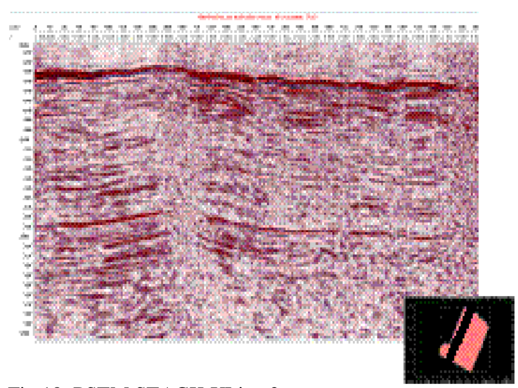


Fig 19 PSTM STACK XLine 2

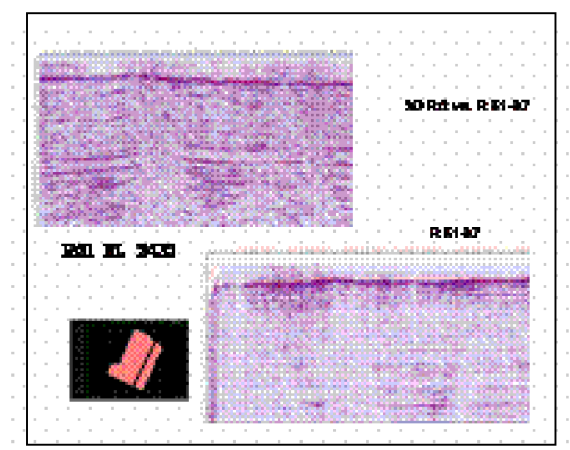


Fig 20 Comparison of 3D RC line with 2D

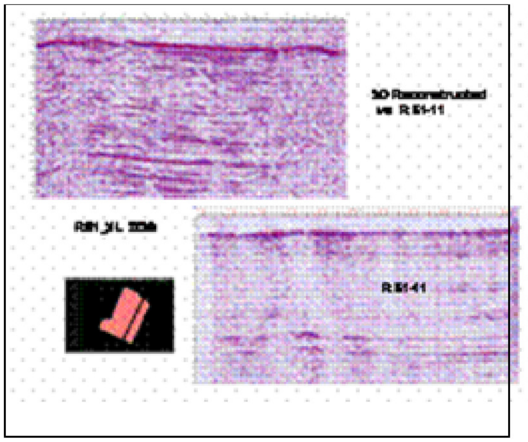


Fig 21 Comparison of 3D RC line with 2D

Conclusion:

New methodology of calculating Statics in volumetric mode appeared to be easy as compared to swath wise approach as the entire data could be seen at one go without any statics shift in adjoining swaths especially in overlapping zone.

The statics so calculated & applied to the 3D seismic data showed remarkable improvements in the subsequent processing stages and better than the statics as calculated from SR operations. Edge effects during modeling could be avoided. Volumetric computation of statics could be made possible incorporating harmonization in overlapping receivers. Thus a methodology for 3D Refraction statics computation in volumetric mode has been established**.**

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