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Improved Imaging through Refraction Statics in a Sand Dune Area: A Case Study.

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Summary

The most common method used in land seismic data processing is to calculate field statics from uphole surveys using elevations of shots & receivers, and the velocities & thickness of the near surface layers. In absence of up-hole data,. Shallow Refraction survey data were acquired to estimate the weathering layer thickness and velocities of weathering layer and sub-weathering layers which in turn is used for calculation of statics. The Field statics thus obtained is applied to seismic data, but the processed stacks could not bring out the desired output over the entire survey area. Only patchy reflections are observed at some places in different stack outputs both at shallower and deeper sections.

Attempts are made to estimate near-surface weathering static corrections by using seismic first-arrival-information acquired in Vibroseis survey based on Generalized Linear Inversion (GLI-3D) program of Hampson-Russell software package. The statics so calculated are applied to the seismic data. It showed remarkable improvements in the subsequent processing stages which are noteworthy and presented in the paper. Also a comparison has been made with field statics, calculated on the basis of Shallow Refraction Survey data as mentioned with the model based refraction statics.

Introduction

The Jaisalmer Basin of Rajasthan (fig1.) is a late Paleozoic basin with Permian rocks resting unconformably over phylite and schist close to Proterozoic age. Baishaki-Bedesar and Pariwar shales are the source rock. It is believed that they are generally gas prone and contain Type III kerogen matter, and have attained maturity over north western part of the basin.

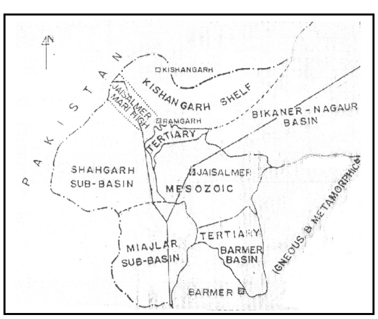

Figure 1 Geological Map of Jaisalmer Basin

The survey area of Jaisalmer basin (fig 2) in Western Rajasthan is covered mostly by steep sand dunes with elevations ranging from 65 m to 120 m (fig 3). These sand dunes cause large increase in the travel times of reflected events in seismic data. The thickness of weathered layer varies from place to place and statics are quite substantial.

It is important to accurately calculate the statics at the time of processing of land data, because this improves quality in the subsequent steps, and in turn, impacts the integrity, quality, and resolution of the imaged section. The situation is much more complicated because of topography existing over the survey area and there is a need to remove the effect of rapid velocity changes in the near-surface or weathering layer.

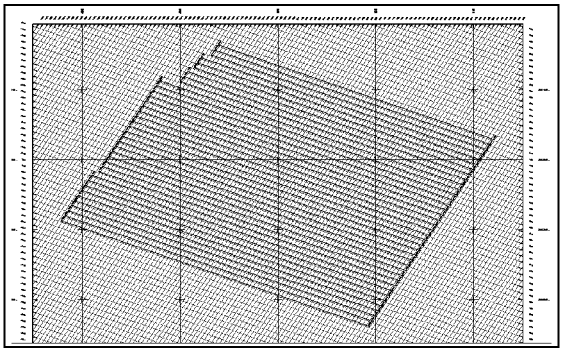

Figure 2 Base Map of the Survey Area.

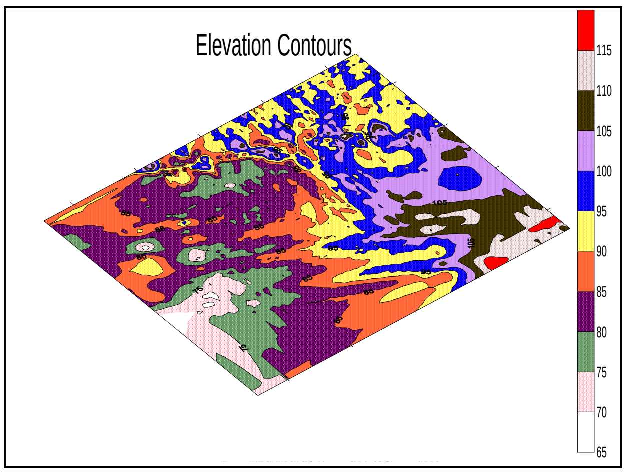

Figure 3 Elevation contours of the area

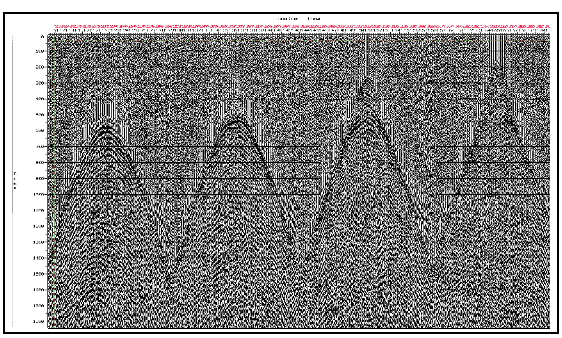

Figure 4 Raw Gather (Vibroseis) Data

The main purpose of 3D Vibroseis survey (fig 4) was to improve the sand channel interpretation (mapping of sedimentary structures and delineation of small stratigraphic & structural features) within the Lower Goru & Upper Pariwar formation of Tertiary and Cretaceous age. Acquisition parameters are shown in Table 1.

Table 1 3D Vibroseis Survey Parameters

Acquisition Parameters	
Type of Spread	Symmetric Split Spread
No. of Channels	144 per receiver line
No. of receiver lines	5
Group interval	40 m
Short interval	80 m
S I & R Length	2 ms ,5sec
Bin Size	20 m x 40 m
Vibrator Parameters	
No. of Vibrators at each V.P.	4
Type of Sweep	Non-Linear (+10 dB)
Varying Sweep	8 - 50 Hz, 8 - 60 Hz, 12 - 80 Hz, 12 - 96 Hz, etc
Sweep length	12 s
Taper length	400 ms
Dry Force	70%
Fold	40

The area is mainly covered by sand dune with NW-SE strike with varying weathering thickness. Correct estimation of statics arising out of the weathering zones is one of the main challenges in data processing and remained the main issue over the years in this part of basin. This has led to a loss in both temporal and spatial seismic resolution. As a result, the processed outputs were not amenable for either structural interpretation or stratigraphic interpretation for lack of resolution.

Static corrections and application

The approach of computing statics on first break information to derive a near surface model is based on some basic assumptions such as horizontal layers or constant velocities. The correctness of the calculated statics is thus dependent largely on the correctness of the near surface model. The methodology involves three steps:

1. Assumption of a basic model (fig 5)
2. Theoretical calculation of the first break derived by ray tracing
3. Comparison of the theoretical first breaks with observed one and minimization of difference.

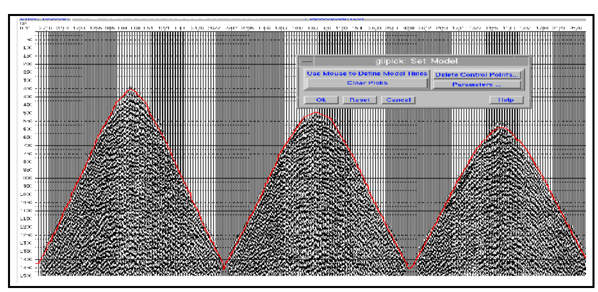

Figure 5 First Break Model of a swath

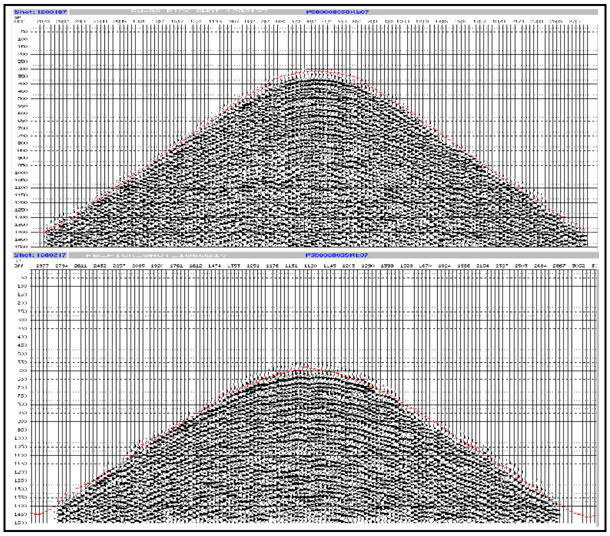

Figure 6 First Break Picks of a swath; Top: near offset, Bottom: far offset

In theory, if first break picking (fig.6) has been done perfectly, it should be possible to model the breaks exactly with a sufficiently complex model. In practice, the model is too simple (fig.7) both because a relatively small numbers of layers is used and because of smoothing of layer thickness and velocities. As a result, some very short-wave details of the real earth model is missing & ignoring them would cause degradation to image seismic data.

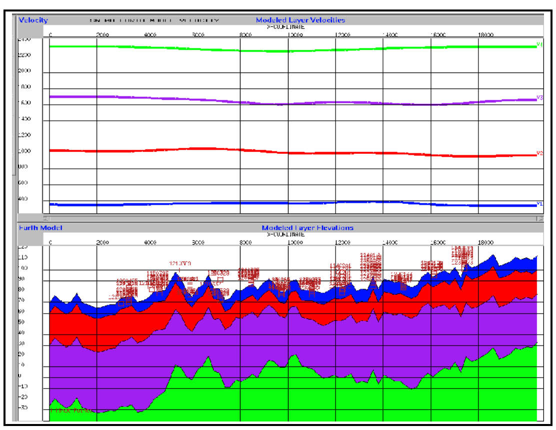

Figure 7 Computed Earth Models (3-layers) of a swath displaying respective velocities at the top

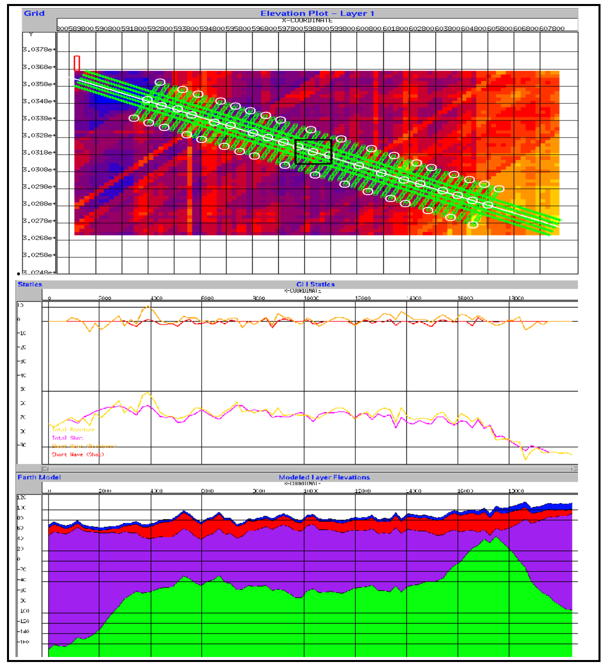

Figure 8 Control points (Top) and final inverted model (Bottom) of a swath

The process handles the short-wave statics by treating them as residual surface-consistent time shifts to be applied after the model based or long wave statics have been calculated. The technique determines its final model (fig 8) by applying the condition that the difference between the actual first breaks and the modeled breaks should be minimized by least squares optimization

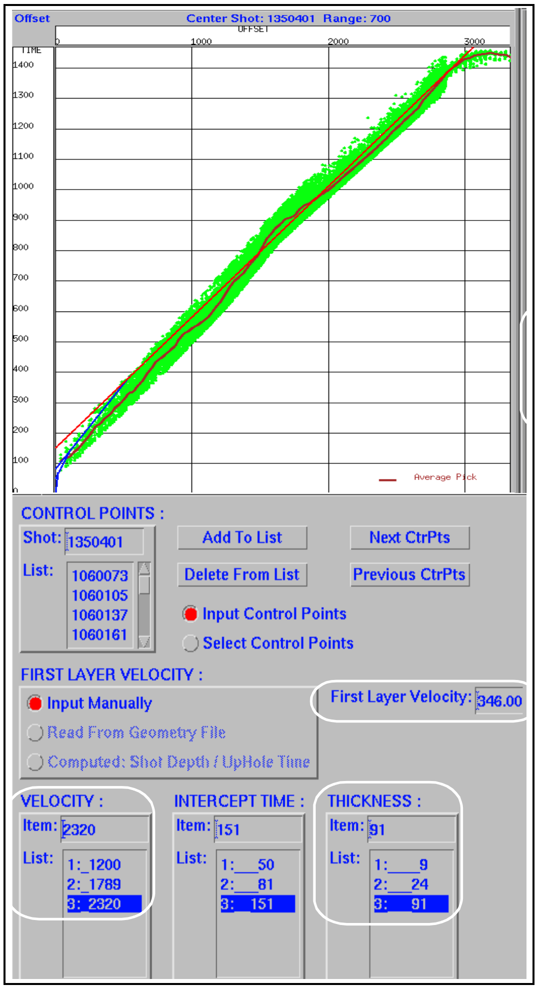

Figure 9 First Break Offset vs. Time Plot of a shot

First break interpretation based on generalized linear inversion was successfully applied in a sand dune area of Jaisalmer Basin, Rajasthan for estimation of statics. The near surface is divided into three layers, the dry weathering on the top of water table, the wet weathering below the water table and the high velocity layer. The velocities of these three layers are 340-480 m/s, 1100-1870 m/s, and 2240-2370 m/s (fig 7 & 9) In contrast, the corresponding values through SR models are 300-510 m/s, 500-1300 m/s and 1100-2600 m/s (fig.10,11 & 12)

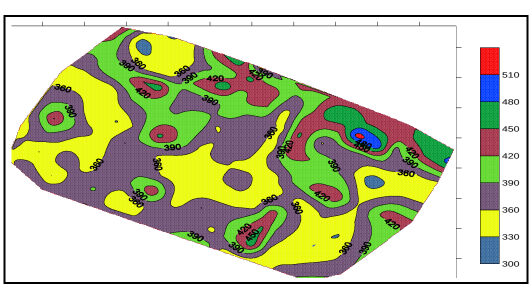

Figure 10 SR based 1st layer velocity model (V0)

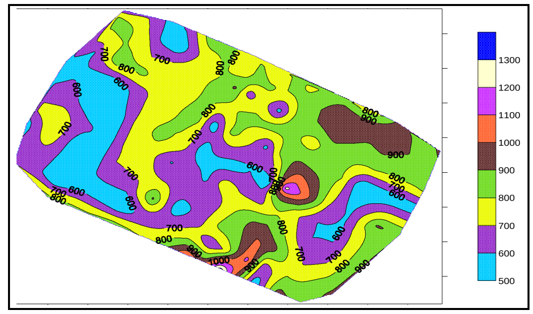

Figure 11 SR based 2nd layer velocity model (V1)

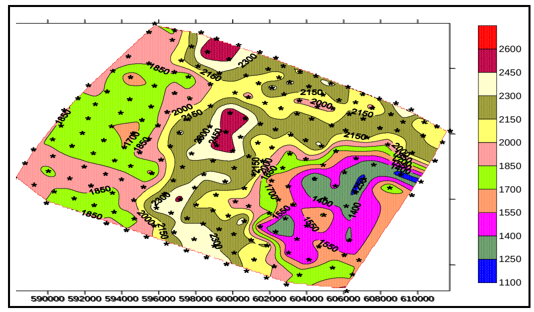

Figure 12 SR based 3rd layer Velocity model (V2)

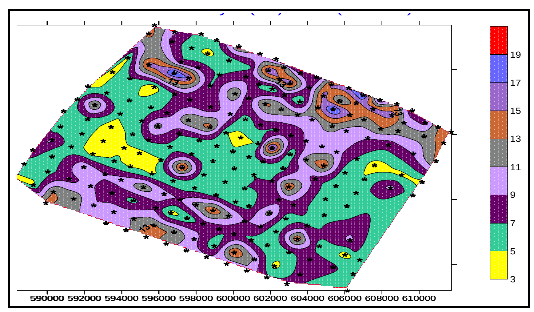

Figure 13 Contour of weathered layer (D1) thickness

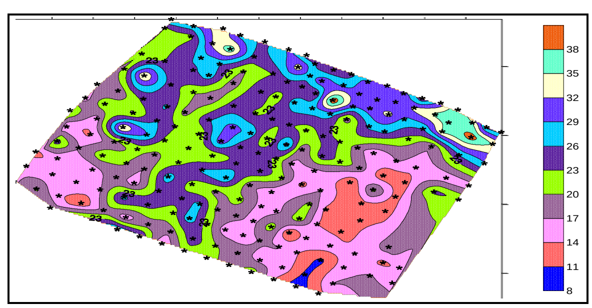

Figure 14 Contour of Sub-weathering layer (D2) thickness

The thickness of the top two layers as calculated by SR data (fig 13 & 14) are 3-19 m & 8-38 m while the values for refraction statics lie between 9-16 m, 19-31 m and 48-92 m(fig 9). The total approach of estimation of statics on refraction data available in the seismic reflection records is summarized through a flow chart in fig.15.

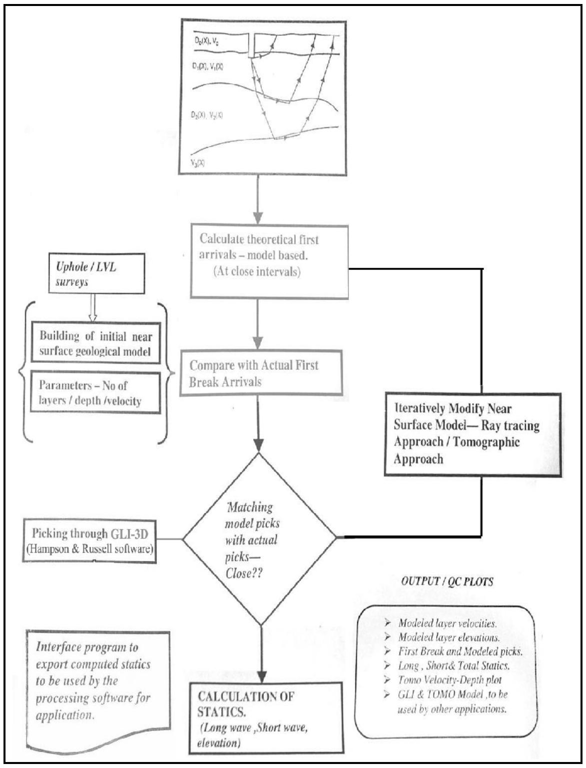

Figure 15 Flowchart showing the route for estimating statics based On Model & First break picks

Results

A comparison with processed outputs (fig 16, 17 & 18) at brute stack level clearly shows the enhancement of continuity at shallower as well as deeper part of the section. In fig 17, it became obvious that with proper statics the cross noise also minimized apart from enhancement of reflections. Further improvement of quality in subsequent steps is noticed in Fig 19 .Though the final processed output of the entire 3D volume is yet to be ready, an In-Line 658 representative residual stack & corresponding migrated output of the so called refraction statics applied data has brought out the desired level of resolution for structural and stratigraphic interpretation (fig 20 &21).

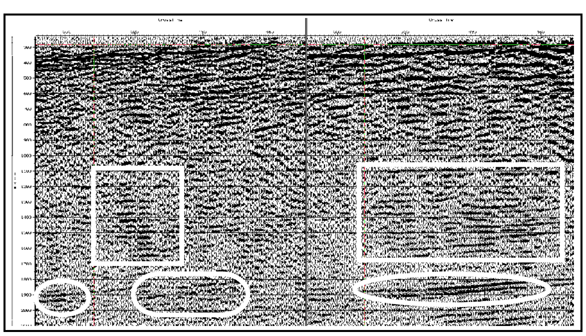

Figure 16 Comparison a) Brute stack with field statics (left) b) Brute stack with refraction statics (right)

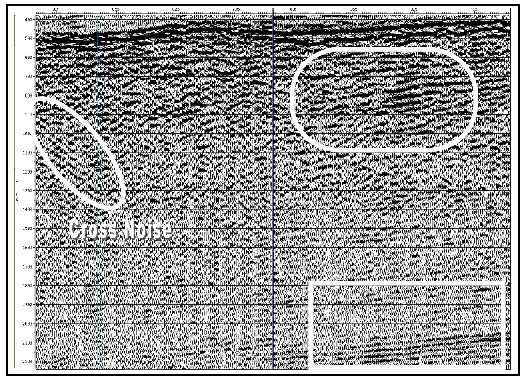

Figure 17 Comparison a) Brute stack with field statics (left) b) Brute stack with refraction statics (right)

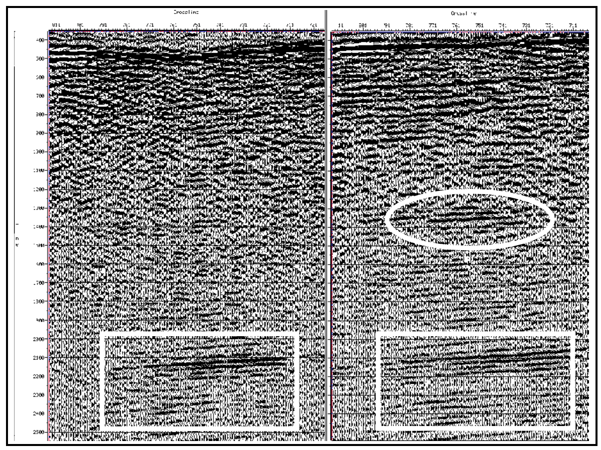

Figure 18 Comparison a) brute stack field statics (left) b) Brute stack refraction statics (right)

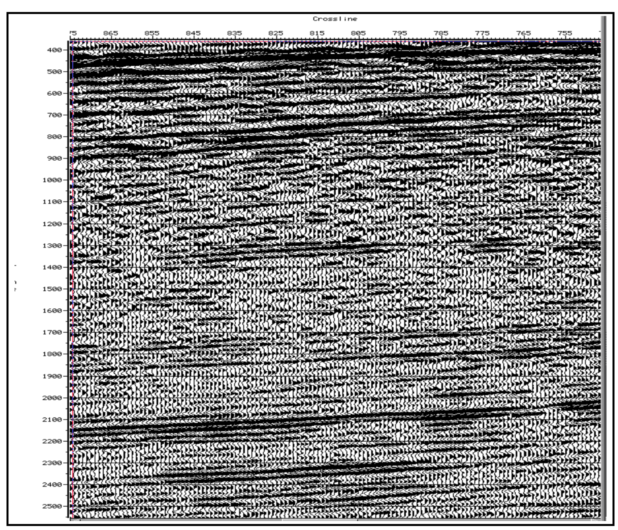

Figure 19 Residual stack In-Line-658

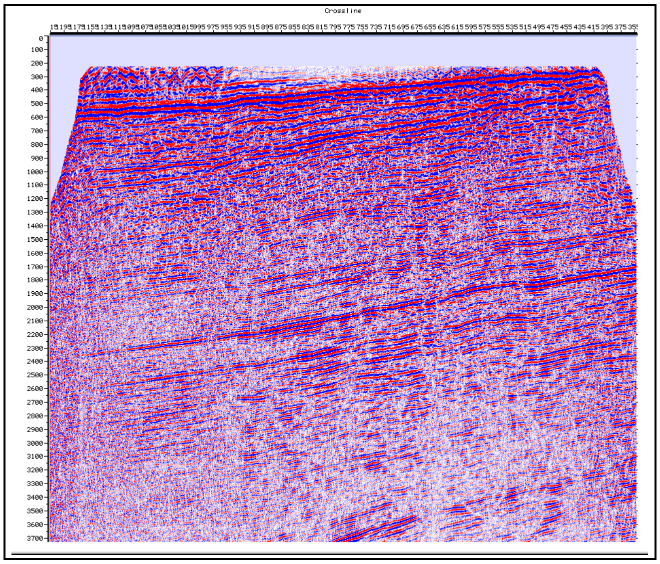

Figure 20 Residual stack

Conclusion

Computation of statics on modeled first break has a distinct advantage and best applicable when field statics are not reliable due to complex near surface especially in the sand dune area. Even if the field static corrections are available, a comparison with refraction statics especially for a terrain with drastic elevation variations establishes the correctness of the correction.

This technique requires to be supplemented with improved first layer velocity for which an accurate near surface model is required for computing earth model from first break analysis. This requirement is met here with the near surface model constructed through SR data supplied by the crew.

Further, the field static corrections calculated on the basis of the model derived from SR survey (fig 22) seem to be incorrect as it consists of less number of control points (t-values) resulting in erratic sub-weathering velocity & thickness of the layers. In comparison, the earth model as deciphered from first break analysis consists of three layers with a higher sub-weathering velocity.

References

Yanpeng Li, Pengyuan Sun, Haishen Yang, Dongfeng Zhang, and Jing Zhou, 2007,
Application of the FBTD converted –wave static method in a sand dune area; First Break, volume 25, May2007.
K V Krishnan, and Randeep Guha, Estimation of statics from refraction data in seismic reflection records; Wiggle, vol 2.2002.
Operational report on 3D Vibroseis reflection survey in Chinnewala Tibba (South of Kharatar) area of Rajasthan by GP-26, ONGC, Jodhpur 2007.

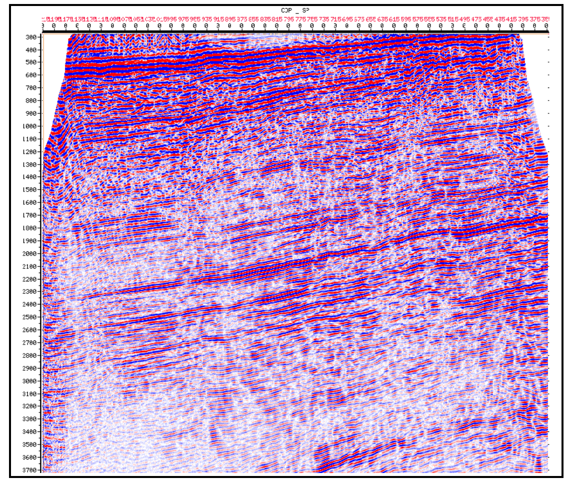

Figure 21 Migration output

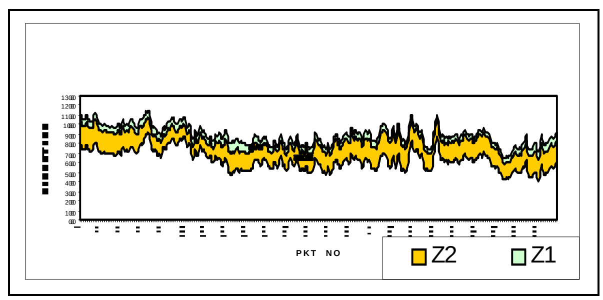

Figure 22 Near surface model derived from SR survey (reverse plotted)

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