Decision of Shooting Medium in Land Seismic Data Acquisition in Areas Having Energy Transmission Problem - A Case Study from Cambay Basin

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Summary

Shooting medium is one of the key elements and impacts directly the data quality in land seismic data acquisition. In course of acquiring long offset (~6.0 Km.) 2D seismic data in Wamaj low area of Cambay Basin, characteristic difference in quality of monitor records was observed due to change in shooting layer. These shooting layers appear to have similar velocity, uphole pulse attributes and lithology, along a part of a seismic profile. These layers however show characteristic difference in signal energy (layer wise) and the relative difference continues to be seen even if velocity in a layer laterally grades down (2000m/s to 1000 m/s). This suggests that the decision of shooting medium is to be made based on energy transmission characteristics rather than based on high velocity and uphole pulse. This can be achieved by analyzing data quality from check shots in different layers. Lateral extent of shooting medium thus found suitable should be tested inspite of velocity grading down considerably. In areas having significant near surface velocity variations, correlation of shooting medium over an area and following it up with the help of check shots will result in better quality data.

Introduction

Wamaj Low, a longitudinal Graben, in Cambay Basin (fig.-1), has sedimentary thickness of the order of 6.0 Km in the deepest part. Frequent near surface velocity and lithological variations and presence of coal seams in the intermediate section (1.2 to 2.5 sec) pose challenge to seismic imaging of deeper section (below 3.5 sec). Most of the vintage 2D seismic data, though acquired for objectives lying in the two way time window of 1.0 to 3.5 sec, show poor signal energy in the section below 3.5 sec barring occasional better amplitude standout in some parts of the area (fig.-3). The lowermost sequence is 'OLPAD FORMATION' consisting of trap wash and shale rich in organic matter. This is believed to be source of hydrocarbons in the sub basin. Olpad Formation is overlain unconformably by 'Cambay Shale' followed by 'Kalol Formation' (fig. 2).Sands in Kalol Formation are hydrocarbon producers in and around the Wamaj Low. Occurrence of coal seams in Kalol and Cambay Shale affect energy transmission in seismic data acquisition and pose a challenge to quality data acquisition. The deeper part is represented by weak reflection events in general, showing better amplitude standout in some patches (fig.-3). The area is under focus for possible 'Deep Basin Central Gas Prospect' based on amplitude anomaly in 'OLPAD SECTION' and analogy from other basins elsewhere in the world.

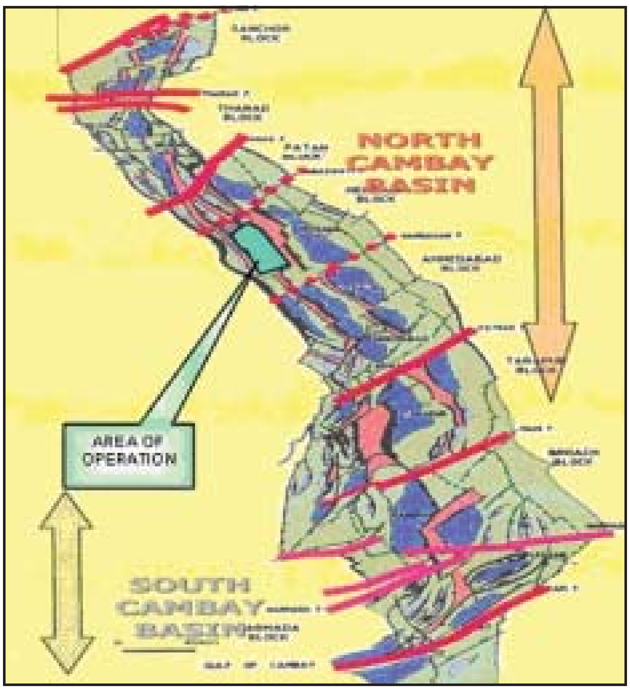

Fig. - 1 Tectonic map of Cambay basin

Near surface velocity model and decision of shooting layer

Fig. 4 a-e show uphole T-D curves at five uphole locations respectively along the seismic line showing different

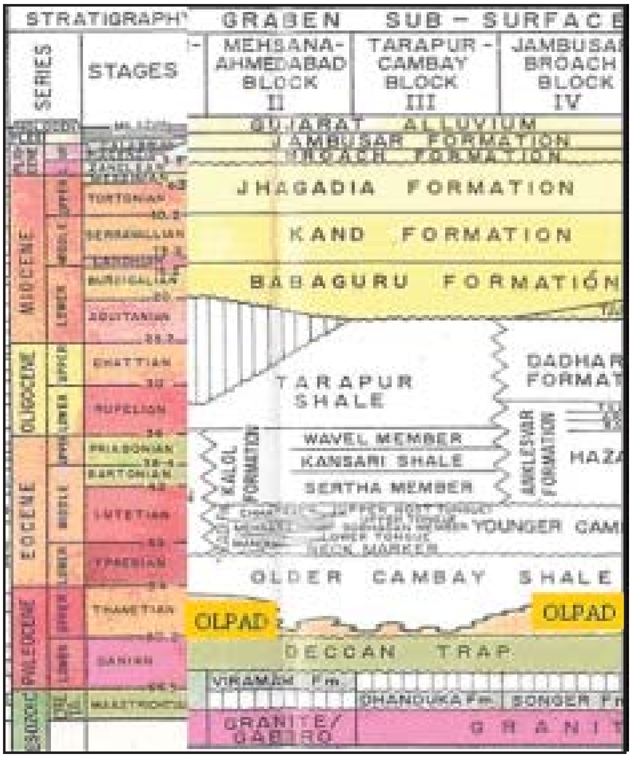

Fig. 2: Stratigraphy of Cambay Basin

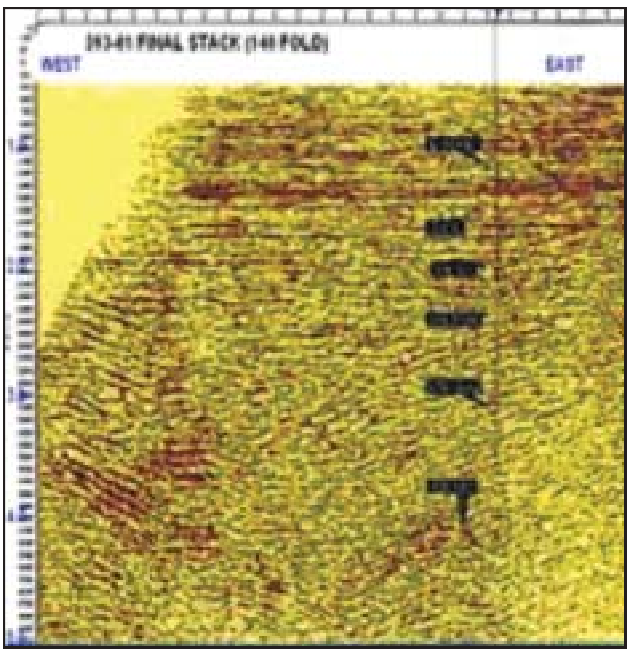

Fig. 3: Seismic section across Wamaj low

velocity layers. Typical uphole pulse signatures (sharp high amplitude pulse) are shown here from uphole 3 (fig 4f to 4h). There are three high velocity layers in the depth zone of 16-26m, 27-40m, and below 42m.

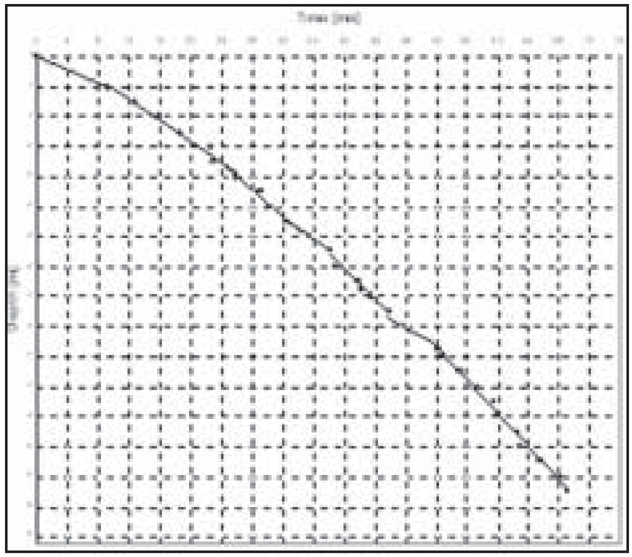

Fig. 4a: UPHOLE - 1

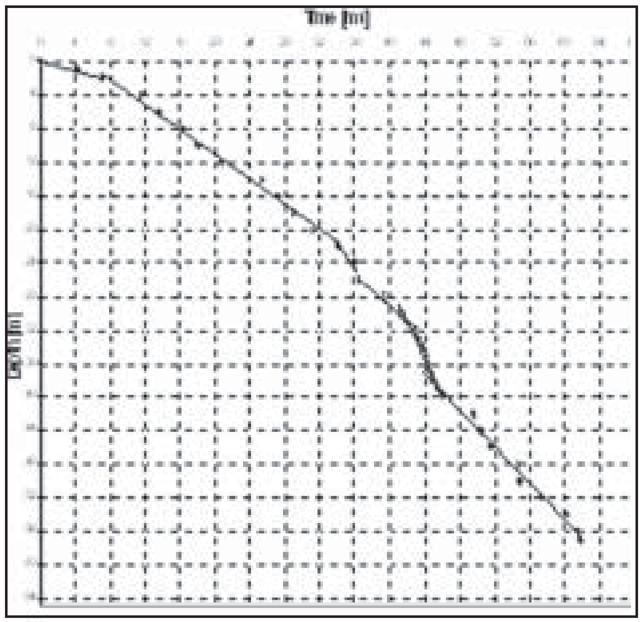

Fig. 4b: UPHOLE - 2

Fig. 5 shows part of the near surface velocity-lithology model prepared based on the uphole surveys conducted, approx. 1 km apart, before acquiring seismic line. Ground elevations, along this part of the seismic line, vary from 60m to 65m above MSL. Thickness of low velocity layers, separating high velocity layers, varies laterally. Lateral variations are seen in all these three high velocity layers. The deepest high velocity layer is seen from uphole 3 to 5.

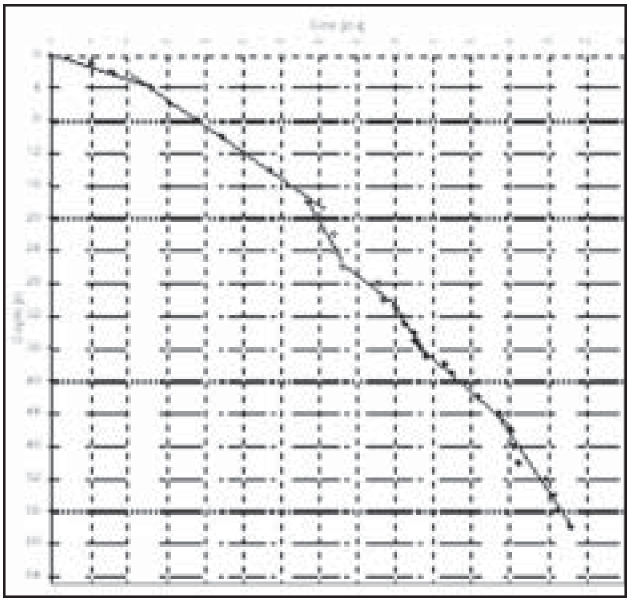

Fig. 4c: UPHOLE - 3

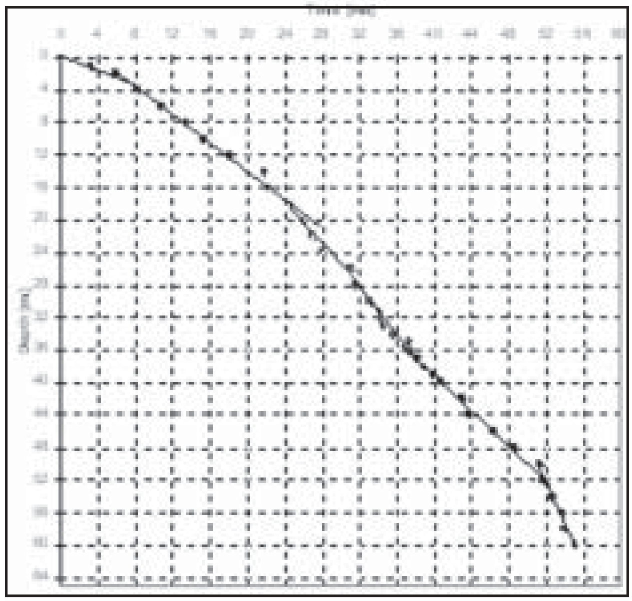

Fig. 4e: UPHOLE-5

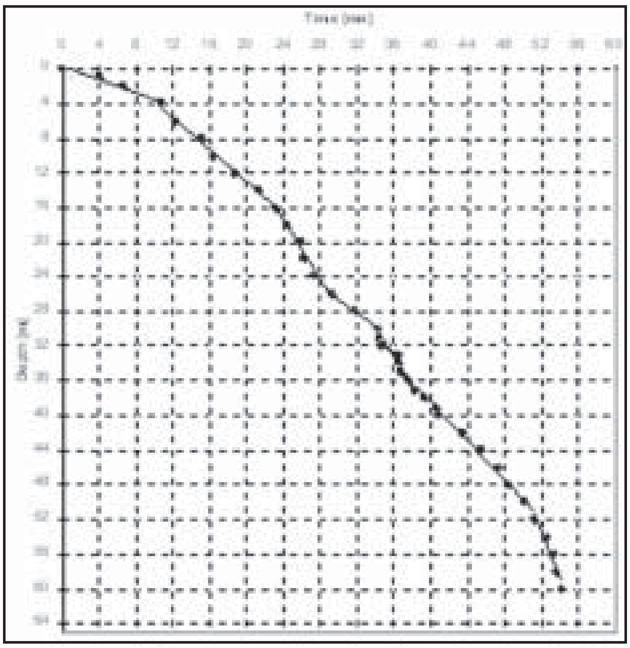

Fig. 4d: UPHOLE-4

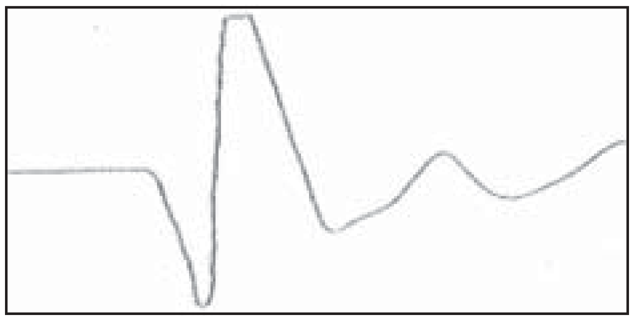

Fig. 4f: Pulse shape (uphole-3)
Depth= 22 Meter, Gain= 72 dB, Detonator= 1 Nos., Explosive= 62.5gm

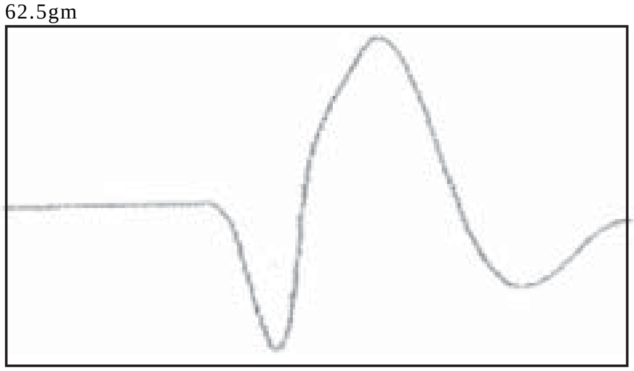

Fig. 4g: Pulse shape (uphole-3)
Depth= 33 Meter, Gain= 60 dB, Detonator= 1 Nos., Explosive= 62.5 gm

The velocity in shallow high velocity layer grades down from uphole 3 to 1 as well as uphole 4 to 5. This layer appears to be losing its identity from uphole 3 to 1. The red color dots show shot hole depths for the part of the line

Recently long offset (6.0 Km) 2D seismic data was acquired to image the area for the lowermost sequence (Olpad Formation) overlying Basaltic Trap. Near surface velocity-lithology models, along the seismic profiles, were prepared based on uphole survey data, in advance to acquisition, to decide shot hole depths. Shot hole depths were decided based on presence of high velocity, preferably

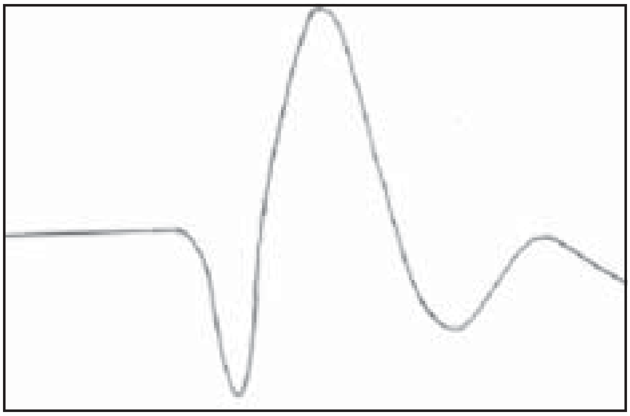

Fig. 4h: Pulse shape (uphole-3)
Depth= 34 Meter, Gain= 60 dB, Detonator= 1 Nos., Explosive= 62.5 gm

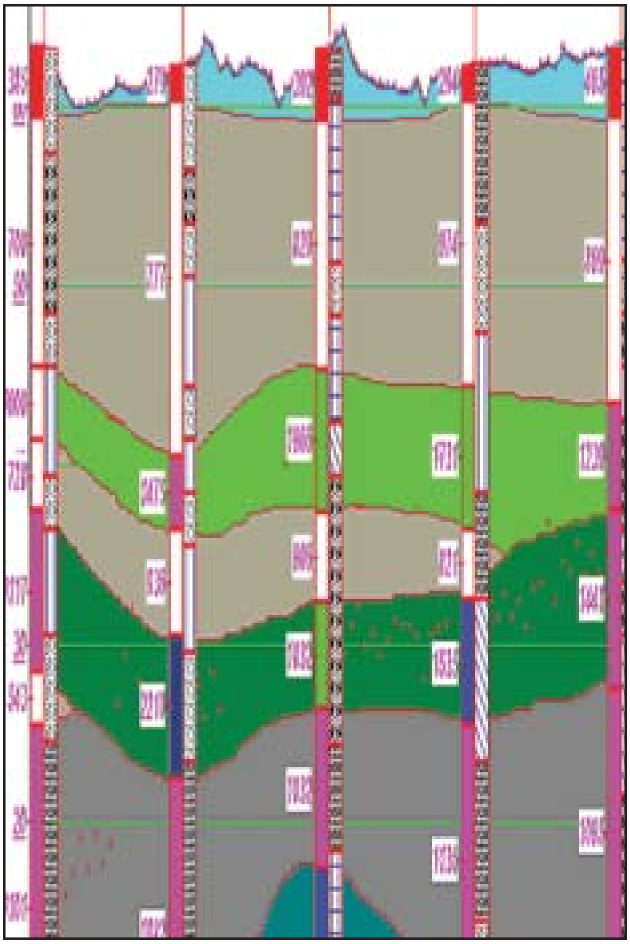

Fig. 5: Near surface velocity-lithology model

clay lithology and sharp-high amplitude pulse recorded in uphole surveys. This methodology for the choice of shooting media is in routine practice in Cambay basin for the acquisition of seismic data. In general this methodology has resulted in good quality seismic data. As already mentioned earlier, this area of Cambay Basin partly poses challenge for imaging reflectors deeper than 3.5 sec and requires larger quantities of explosive (5 – 10 kg per shot) to be blasted to have sufficient energy.

Data analysis and results

While acquiring long offset 2D seismic survey in the area, Co-incidentally there are certain records from shallower depths though intended to be deeper but not drilled due to practical problems. Such records are(from shallow high velocity layer) shown in fig. 6 to 8.

Analysis of the field monitor records vis-à-vis shot hole depth, near surface velocity, lithology and pulse attributes from uphole surveys, resulted in a special observation which can be used as a feed back to improve

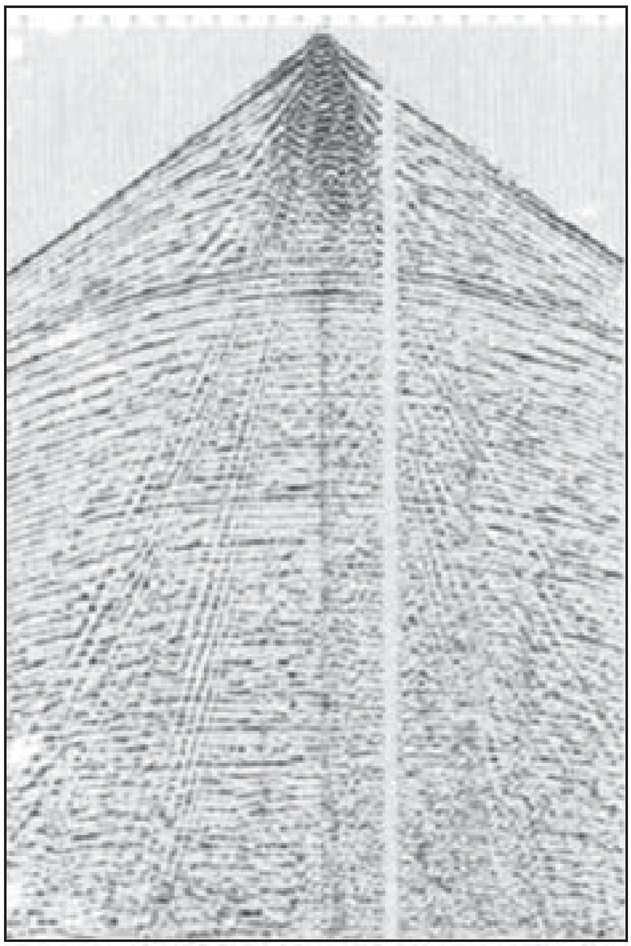

Fig. 6a: Field monitor record at 25.0m in shallow high velocity layer on cross line close to uphole-5.

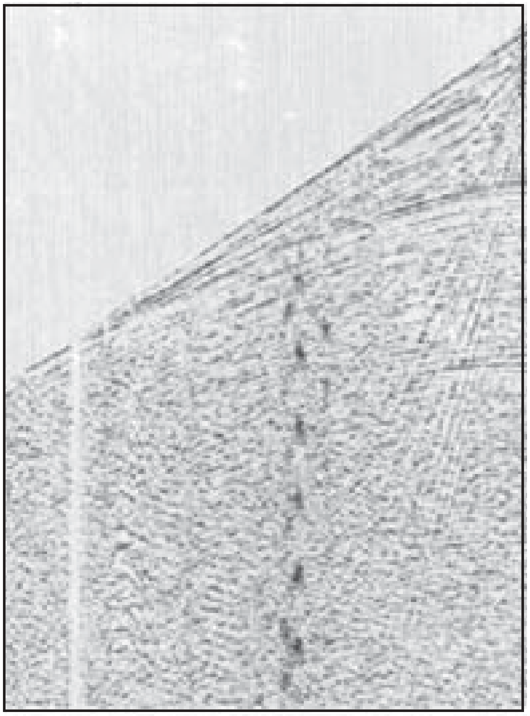

Fig.6b: Field monitor record at 28.5m in middle high velocity layer at uphole 5 location.

upon the process of shot hole depth optimization, particularly in this area.

Fig. 6 to 8 are showing field monitor records for the deeper high velocity layer as well as from shallow depths falling in shallower high velocity layer, at the same or an adjacent location. Very good signal energy in deeper section below 3.5 sec is evident on the monitor records from shots blasted in the shallower high velocity layer in contrast to those from deeper high velocity layer. A layer having seismic response like that of the shallow layer, shown in fig 6 to 8, could be preferred over the deeper layer(mainly the high velocity layer in the middle), considering mainly the amplitude stand out even in the deeper section. Frequency (apparent sharpness of seismic events) on records from shallower high velocity layer appears to be marginally lesser than that from deeper high velocity layer.

The shallow layer exhibits high velocity very locally (uphole 3 & 4 in fig. 5) extending laterally with velocity grading down from uphole 4 to 5 and from uphole 3 to 1. Records from shallow high velocity layer (fig. 6 to 8) show better signal energy and sharper events with increase in velocity in the same layer. Lateral consistency of seismic

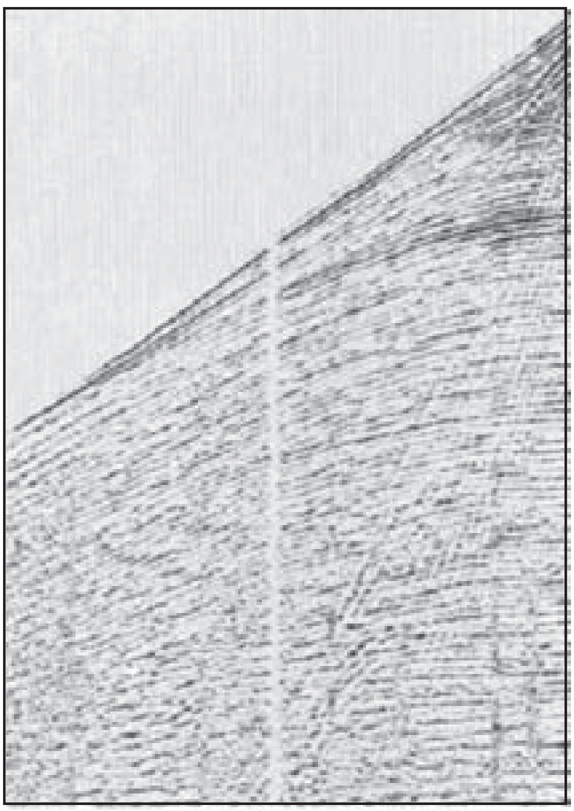

Fig. 7a: Field monitor record at 23.5m in shallow high velocity layer at uphole-3.

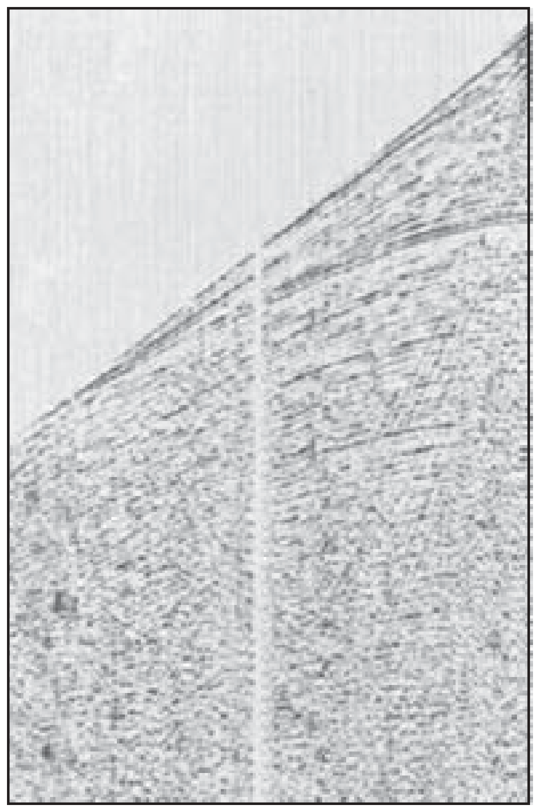

Fig.7b: Field monitor record at 35.5m in intermediate high velocity layer at uphole-3 location.

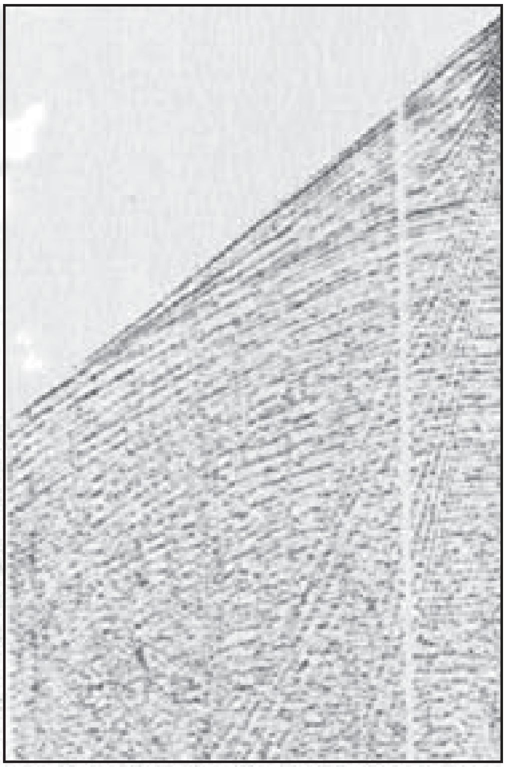

Fig. 8a: Field monitor record at 21.5m in shallow high velocity (graded down) layer close to uphole-1 location.

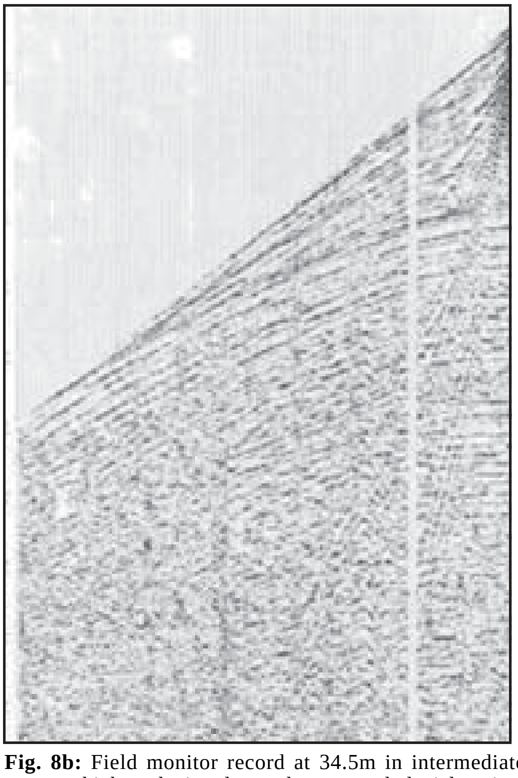

Fig. 8b: Field monitor record at 34.5m in intermediate high velocity layer close to uphole-1 location.

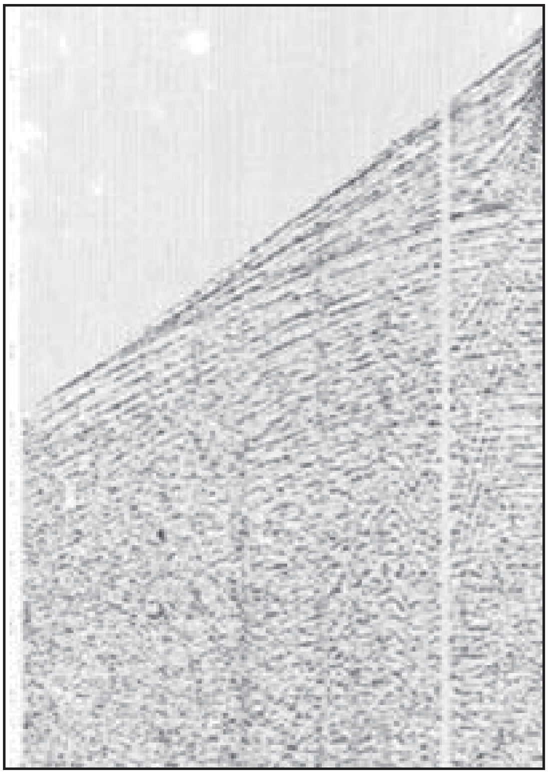

Fig. 8c: Field record at 43.4m below intermediate high velocity layer close to uphole-1 location.

energy transmission of the shallow high velocity layer supports the view that inspite of the layer velocity laterally grading down considerably, the better seismic energy transmission from shots in this layer continues to be seen and it offers as an optimum shooting medium with lower cost and ease in drilling.

Conclusion

Generally high velocity preferably with clay or water saturated sand lithology and sharp – high amplitude uphole pulse are general attributes of a layer to be selected as shooting medium. This needs to be validated by analysis of signal energy on monitor records of check shots from such layers and the shot hole depths can thus be optimized.

Different layers having individually considerable attributes like lithology, velocity and pulse characteristics, may have drastically different energy transmission. Preferable layer, based on desirable signal energy on monitor records, can be pursued as shooting media as long as desirable signal energy continues to be seen laterally even if the layer appears to be loosing its identity on uphole data.

In areas having significant near surface velocity variations, correlation of shooting medium over an area and following it up with the help of check shots will result in better quality of seismic data.

Acknowledgements

Authors are grateful to Oil & Natural Gas Corporation Ltd., India, for providing facilities to carry out this work. Authors are indebted to Director (Exploration), ONGC for his kind consent for presentation and publication of this paper. The authors acknowledge Shri B. Lal for the valuable discussion and support.

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

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