IMPROVEMENT OF SEISMIC DATA QUALITY USING PRIOR TEST SHOT INFORMATION IN HIGHLY UNPREDICTABLE WEATHERING LAYER

(A Case Study from Cambay Basin, India)

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Key Word: Up Hole, Weathering Layer, Optimum Depth (OD)

Summary

Onshore seismic data acquisition with explosive as source is usually carried out by placing charge at Optimum depth (OD) selected based on the up-hole data. In most cases, this is the key to get good quality seismic data. In areas where decisive ODs could not be fixed effectively with the up-hole information, it is found that close monitoring of daily production data and planning of test shots prior to actual data recording helps tremendously in getting good quality data. In the present study, the seismic data quality was severely affected by a sandy paleo- channel with rapid variations of the thickness & lithology of the weathering layer.

Introduction

Cambay basin is one of the petroliferous basins in India with a number of oil & gas fields under production. In the survey area, existing 2D data interpretation revealed the absence of any structural play. The stratigraphic plays identification was one of the main objectives of the 3D seismic data acquisition in the study area. The presence of nearby producing fields (Gamij & Bakrol) makes this project very exciting and important. Highest consideration for data quality was therefore accorded right from the start of the data acquisition without any compromise.

Based on the inputs on the problems faced by the operators in the neighboring blocks, it was known that the presence of a 'kankar' formation within weathering layer would pose a challenge to locate suitable lithology while optimization of the OD in order to achieve high level of energy transmission in the sub-surface.

The conventional approach of using up-hole data to determine the thickness and depth of the weathering layer does not always work across different geological situations. In the study area, presence of thin high velocity layers embedded in weathering/sub-weathering layer of rapidly varying thickness and extent was a cause of large variations in near surface velocities. A uniform model hence could not be established for fixing the shot-hole depths using uphole data. After detailed experimentation with the various field parameters and up-hole depths, a method was devised to record the test shot data with variable charge size and depths for progressive swaths prior to production recording. The charge depth and size at the test shot locations was selected based on the up-hole data and the quality of seismic data of the preceding swaths. The final charge size and depth for the production shots were further optimized based on the quality of these test records. This approach has helped in addressing the problems caused by the unpredictable weathering layer that could not be addressed by uphole survey and enabled recording of good quality seismic data in the study area, without much variation in the acquisition costs.

Study Area

The study area lies near the Eastern Basin Margin of the Ahmedabad sector of Mehsana- Ahmedabad tectonic block in the intracratonic, rifted Cambay Basin. The area has gentle relief and the main physiographic feature is the southwest flowing Meshwa River, which traverses across the block (Figure-1). Paleo-channels of this river are also seen in the satellite images. 3D Seismic data was acquired in the dry season from January to May.

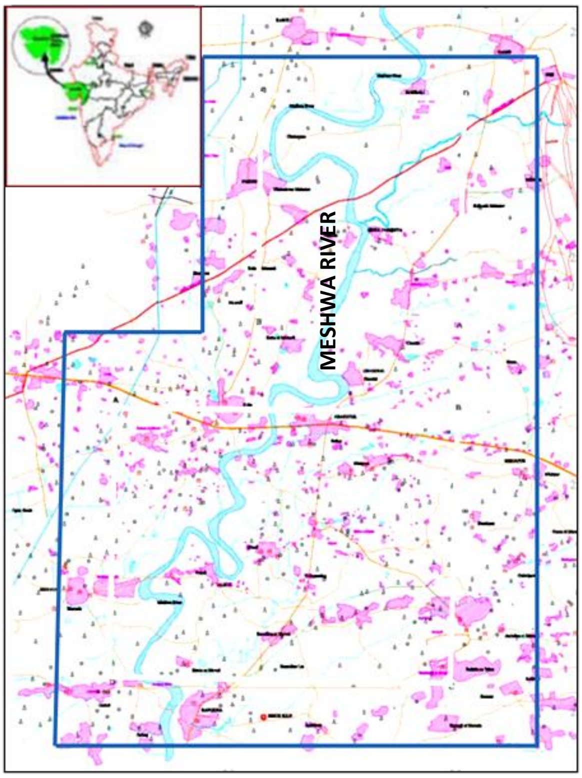

Figure-1: Location map of the study area

Methodology

Objective of seismic data acquisition is to record seismic signal from different acoustic boundaries in the subsurface. For achieving this, explosive charge is loaded at suitable depth (high energy medium below the weathering layer enabling most of the energy to transmit into the subsurface with least absorption) and subsequently it is blasted for generation of acoustic waves that propagate and reflect through different successive sub-surface layer boundaries. The reflected energy is recorded by seismic recorder at surface.

The up-hole data was recorded in a grid of ~ 1x1 km^2 to get the near surface velocity/depth model of weathering layer in the survey area. The quality of up-hole data was good and initial seismic data acquisition was planned based on this up-hole information. Based on seismic data quality of initial swaths it was realized that the charge depth determined for the shot holes was probably not optimized due to severity in the variation of weathering layer thickness. Some uphole data suggested multiple options for OD but as a definite program (with OD) had to be given to shot hole drilling crew in advance, QC geophysicists were faced with this dilemma of assigning OD for next day of shooting on every day basis. The seismic data quality also varied from shot to shot in the area. Some of the shots had given good data quality while others had very poor data. This random variation in quality of data was a problem in-hand to deal with. Attempts were made to improve the data quality without any significant success.

A new approach was adopted to record the test shots prior to actual production data. The full acquisition spread of the previous swath was utilized to record these test shots for finalization of shot hole depths for the next swaths (Figure-2). The charge depth for the shot holes of a particular swath was selected on the basis of the quality of data of the test records. This method was adopted for entire study area.

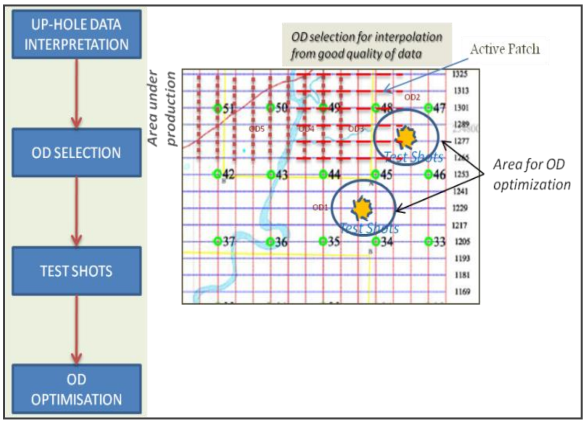

Figure-2: Schematic diagram of methodology for OD optimization

Analysis & Results

Generally, Up-hole data helps in deciding the optimum depth (OD) with identification of the high energy (velocity) strata before start of 3D seismic data production. Therefore, to optimize the shot hole depths, up-hole data recording carried out at a spatial grid interval of 1x1 km^2. Since in most of the area the shallow subsurface was highly varying within short spatial distances, it was very challenging to identify the high energy strata to place the charge and hence charge frequently landed in a low energy strata. This had caused considerable wastage of time and resources in repeating the records in addition to compromising with data quality in some instances. In the initial phase of seismic survey, the quality of data was adversely affected.

The challenges faced during selection of OD were as follow:

i) Pebble/boulder ('Kankar') layer depth upto 30m
ii) Low velocity layer below 40-50m
iii) Abrupt change in layer thickness within few hundred of meter (laterally) which led to miss the high velocity layer/ strata

Spatial distribution of existing up-hole data did not offer enough control to identify the depth of shallow subsurface high energy interval. In some areas up-hole interpretation suggested two or more alternatives of Optimum Depth (OD) (Refer Figures -3 a & b).

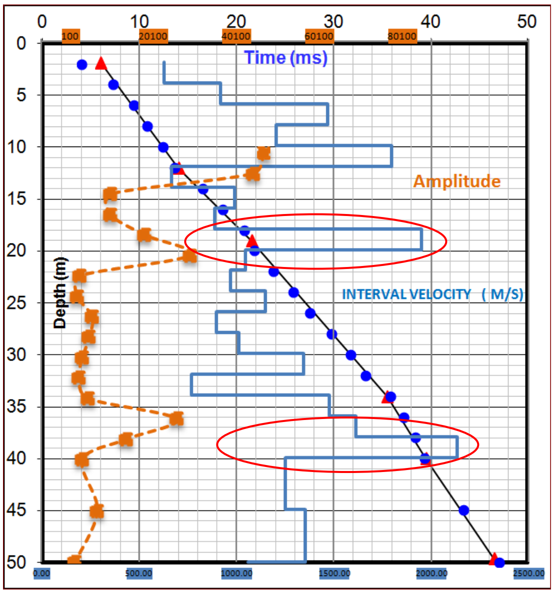

Figure-3 a: Interpretated Uphole data showing two alternatives of Optimum Depth (OD).

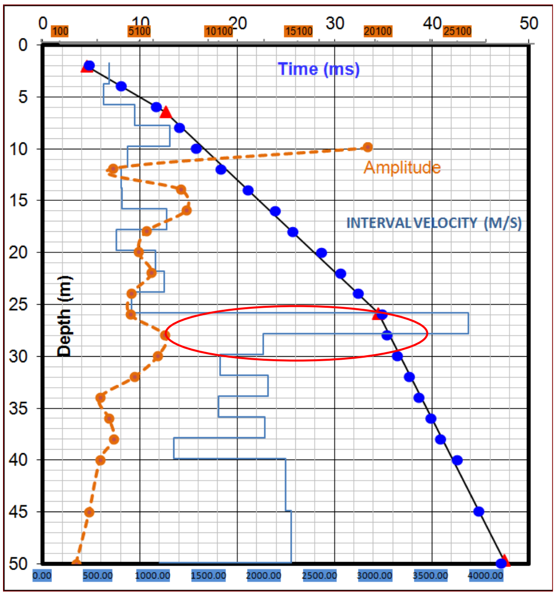

Figure-3 b: Interpreted Uphole data showing one Optimum Depth (OD)

In areas where uphole data interpretation could not suggest a unique OD and multiple OD options were suggestive, it was decided to fix the OD by examining the data recorded with two or more ODs. This option was cumbersome as it was not possible to change the OD on the spot on the day of shooting. This lead to an unconventional approach to record test shot data by using the active spread of the day for those salvos where OD had to be decided (usually 2-3 days in advance). These test records are normal seismic records which provide physical proof of quality of data and helped immensely in finalizing optimum depth (OD) for regular shooting.

In the approach presented here, a suitable Shot Point (SP) station is selected to carry out the test shooting with various charge depths. After examining the data quality of those test records, suitable high energy shallow sub-surface depth was selected for production shooting. OD map prepared based on the uphole data before start of production shooting and OD map generated for actual production shots based on OD's of good quality monitor record and test shot record are shown in figure-4 & 5. As it can be seen from the two maps, there are significant changes in final ODs as compared to what was envisaged from the uphole data alone.

As part of the OD optimization, a base map was updated with source points for marking daily production data as good (green) or bad (red) and OD of the source points. Thus, ODs having good quality records were used for nearby shots (interpolation) rather than ODs suggested by up-hole (Figure-7 & 8).

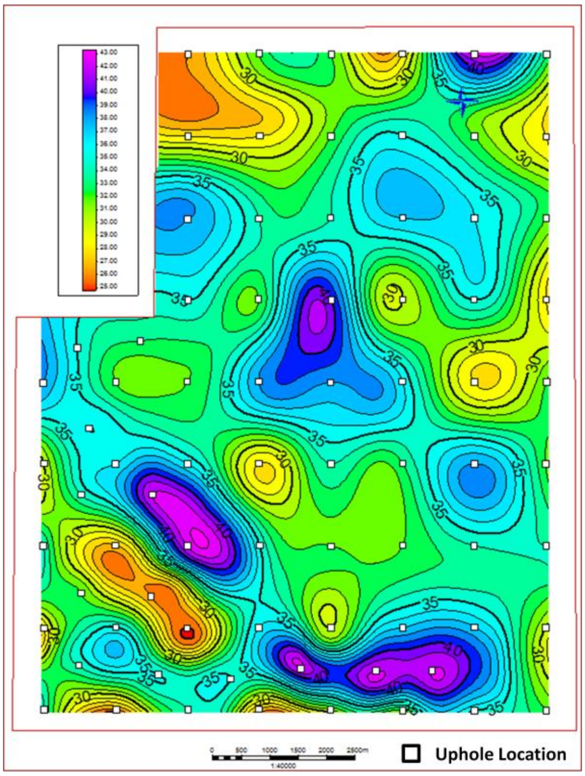

Figure-4: Finalized OD Map based on Uphole data before start of the production.

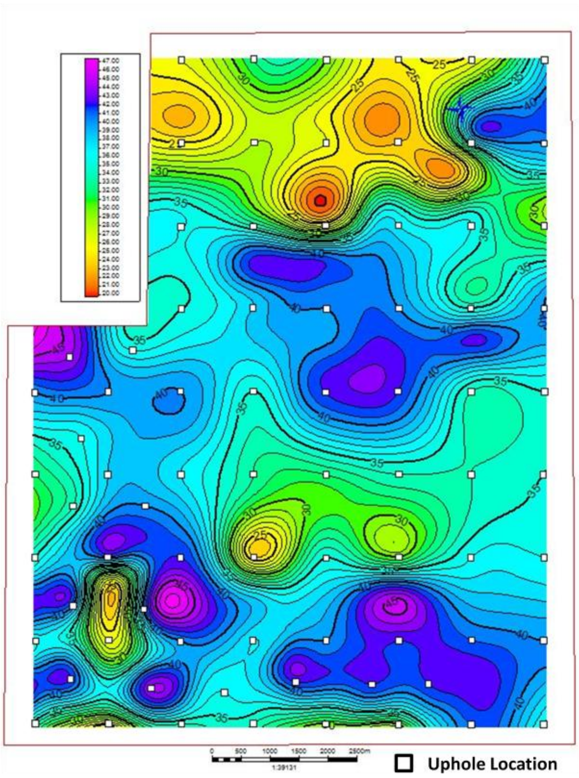

Figure-5: Actual OD Map based on day to day data quality of daily shot records and test shots records

Figures 6 (a, b, c & d) show one such test record at various experimental depths. Based on the quality of the shot gathers, OD was selected. As shown in figures below, Test shot with depth 30m (figure 4a & b) is a bad quality record, whereas shots taken with 42m (figure-4 c & d) has a good quality record.
The quality of seismic data was improved significantly by using this approach (Figures 5 & 6).

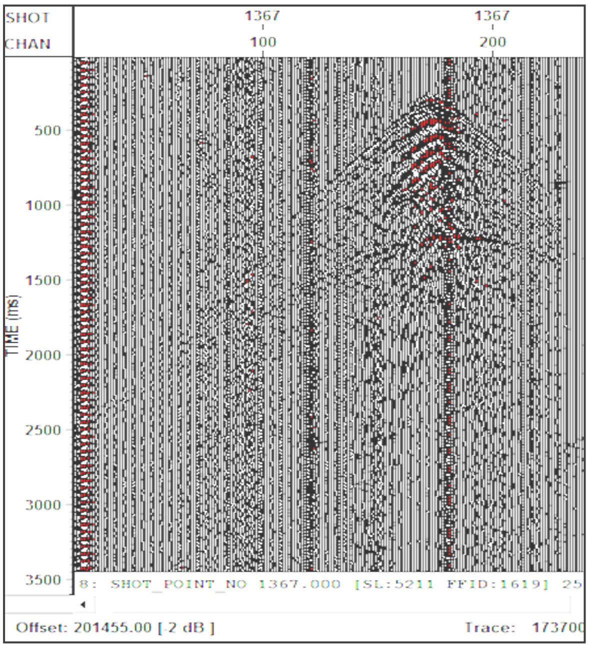

Figure-6 a: Test shot with depth – 30m & Charge Size- 5 Kg (Near offset)

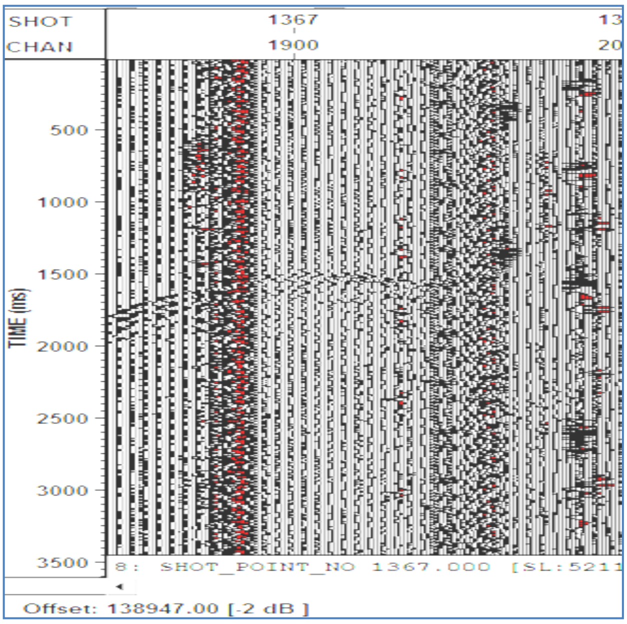

Figure-6 b: Test shot with depth – 30m & Charge Size- 5 Kg (far offset)

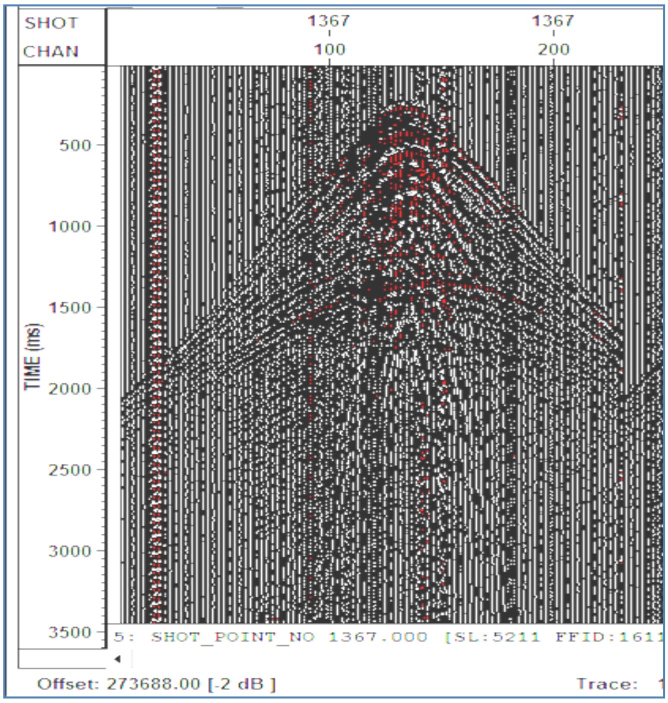

Figure-6 c: Test shot with depth – 42m & Charge Size- 5 Kg (Near Offset)

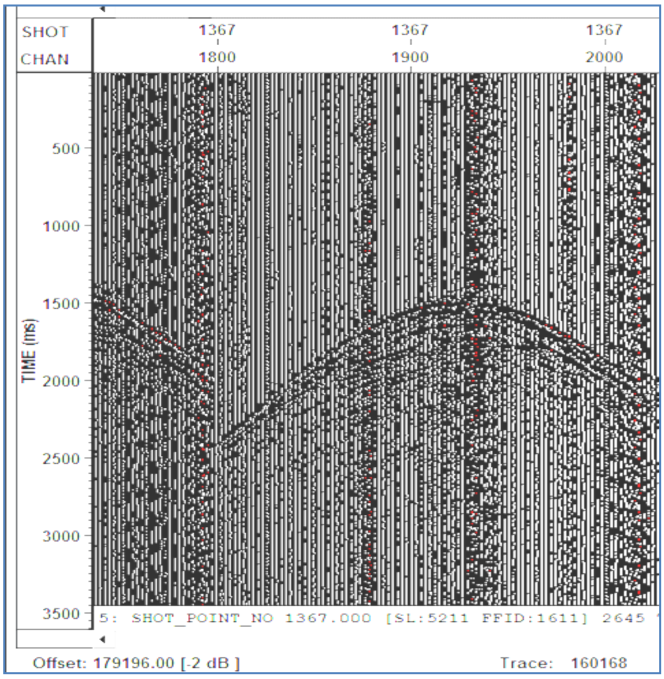

Figure-6 d: Test shot with depth – 42m & Charge Size- 5 Kg (Far Offset)

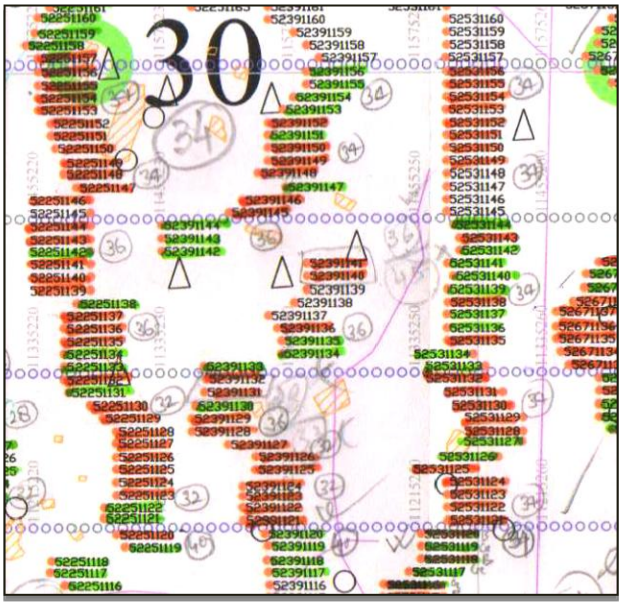

Figure-7: Basemap showing the shots having Bad data quality (red)

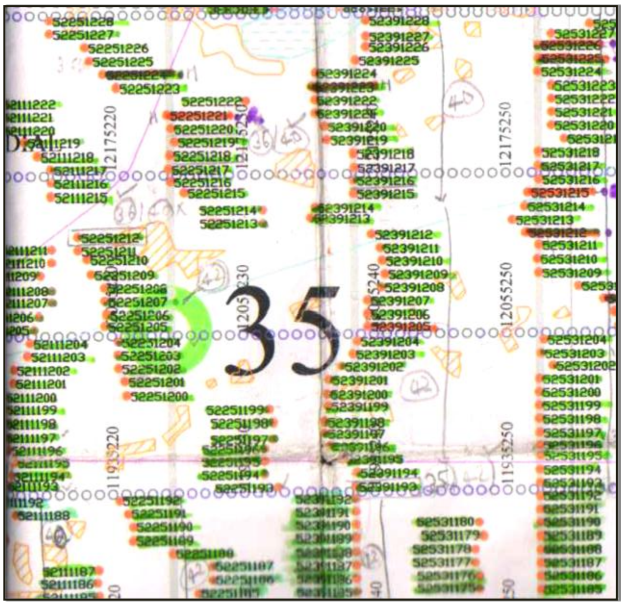

Figure-8: Basemap showing data quality improvement (green) after test shot shooting

Conclusions

In areas where river bed lithology and widely varying depth of weathering layer poses a challenge to record good quality seismic data, a better control on OD selection can be achieved by either dense up-hole data recording or recording test shots based on sparse up-hole data. The test records also provide real time data quality monitoring, which has immense benefits in recording good quality seismic.

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References

1. ***"Decision of Shooting Medium in Land Seismic Data Acquisition in Areas Having Energy Transmission Problem- A Case Study from Cambay Basin"*** by *Ram Kumar*, *U. P. Singh*, Geophysical Services, ONGC; SPG Publication 2006.