9th Biennial International Conference
& Exposition on Petroleum Geophysics

"HYDERABAD 2012"

P-269

An Approach to Understand the Near Surface Parameters for Seismic Survey in an Unknown Area

Dilip Kumar Sinha*, T Krishna Prasad, *ONGC*

Summary

Gravity-Magnetic exploration was first carried out in Cambay Basin in 1956-58 and the first 2D seismic survey in this basin was done in 1957-58. Since 1957 till date, ONGC has made large strides from single fold to multifold, from 24 to 4000 recording channels in 2D, 3D, 4D, and 3D-3C seismic data acquisition. Understanding of near surface is an important aspect for getting good quality seismic data, which results in better sub-surface imaging. Weathering and sub-weathering layer thicknesses, velocities and lithology play a vital role in determining good shooting media to get good quality seismic data. Seismic crews conduct close grid uphole surveys combined with pulse data for fine tuning to understand the near surface parameters and in selecting the proper shooting medium.

The paper mainly deals with study of near surface information in unknown area and by generating various maps such as weathering, sub weathering velocities and its thicknesses, with the help of the Uphole data of the adjacent pre-surveyed areas. Near surface Models (NSM) were generated in the desired direction, which helps in giving an idea about the sub-weathering velocity information. Coupled with the information of lithology and pulse data, an understanding of the area in terms of shot hole parameters can be assessed, which helps in planning, reducing the cost and better time effective.

Introduction

Brief Geology: Cambay basin came into existence at the end of Mesozoic time during late Cretaceous when tensional faults developed along the ancient basement trends. The basin started rifting perpendicular to the two major eastern and western margin faults, which formed parallel to axis of basin, probably parallel to NNW-SSE Dharwarian trend. A number of uplifts and depressions (in the form of half graben and full graben) developed parallel to the axial trend. Subsequently the basin developed a number of transverse and cross trends which is differentiated the basin into major morpho-tectonic blocks Sanchor, Mehsana, Ahmedabad, Cambay, Tarapur, Broach and Narmada. The cross trends are active areas for migration of hydrocarbons.

The entire Cambay basin is divided into five tectonic blocks based on transverse fault system which might possibly be subsequent to the longitudinal fault system, although originating within the basement itself. From North to South these tectonic blocks are as follows.

Narmada	–	Tapti
Jambusar	–	Bharuch
Cambay	–	Tarapur
Mehsana	–	Ahmedabad
Patan-Ttharad	–	Sanchor

The study area is in Cambay-Tarapur block of Cambay Basin, where seismic survey activity is very dynamic and active.

With the introduction of new technologies exploration activities increased in multi fold, uphole surveys are being done for the purpose of understanding the sub surface in a better way which gives weathering and sub-weathering layer thicknesses and velocities. Lots of emphasis is being given on Near Surface Models (NSM) for proper selection of optimum depth with the help of pulse study. NSMs were generated in inline and cross line directions using the weathering and sub weathering layer thicknesses and its

Geophysical Services, Western Onshore Basin, Baroda.
dikusi@yahoo.co.in

velocities from its uphole results. This optimum depth will be chosen from the NSM's with the help of pulse data for placing charge for better seismic energy transmission.

The study block contains three areas namely Area- 'A', 'B', and 'C'. One seismic crew acquired data (Fig.1), with the total number of 316 upholes in Area 'A' and another seismic crew acquired data (Fig. 2), with the total number of 234 upholes in Area 'B'. The uphole locations of the two combined areas were plotted, a gap was found between the areas 'A' and 'B' is area 'C' (Fig. 3) where no data was available.

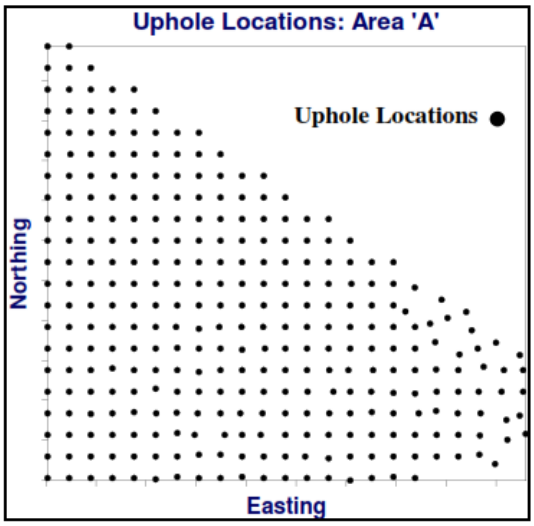

Fig. 1- Uphole Location: Area 'A'

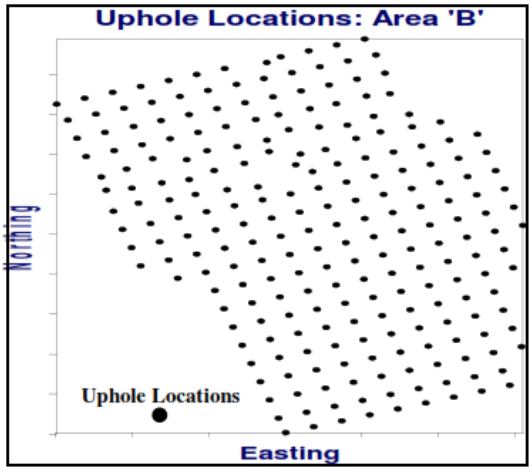

Fig. 2- Uphole Location: Area 'B'

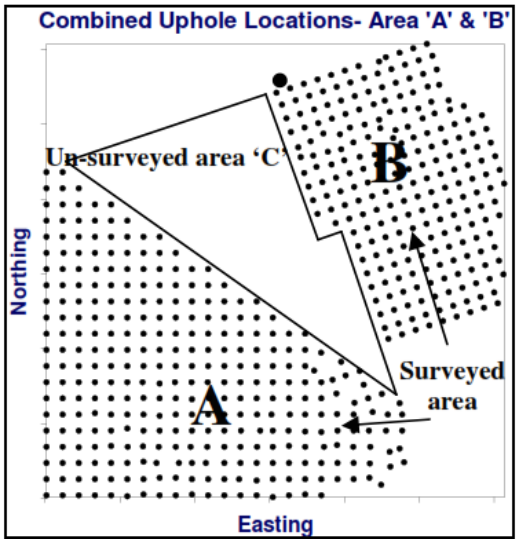

Fig. 3- Combined Uphole Location Map

Methodology

In order to understand near surface parameters of the un-surveyed area 'C', area wise detail uphole results, viz uphole location, its easting/ northing, depth, elevation, weathering thickness (T1) with velocity (V1) and sub-weathering layer thicknesses (T2) with velocity (V2)were obtained from the uphle survey, relooked for correctness and created a data base. A sample of uphole survey result (UH-28 in the study) is shown in Fig. 4, where time depth plot, lithology, pulse plot are shown. The first low velocity layer is called weathering layer (Thickness T1& velocity V1). The next high velocity layeris known as sub-weathering layer (thickness T2 &velocity V2).This layer is chosen for placing the charge for shooting depending upon lithology and velocity. Within the help of pulse shape and its strength, optimum shooting depth will be selected for better transmission of seismic energy. The details of uphole location, T1, T2, V1, V2 etc values are stored in the database. This was done for all the upholes of the two areas under study to generate the data base. Sample data base is shown in Table1, where Elevn & TD stands for elevation of the location and total drilled respectively. Its part zoom portion is shown in table 1a. The data base can be used to study in an unknown area between two known areas.

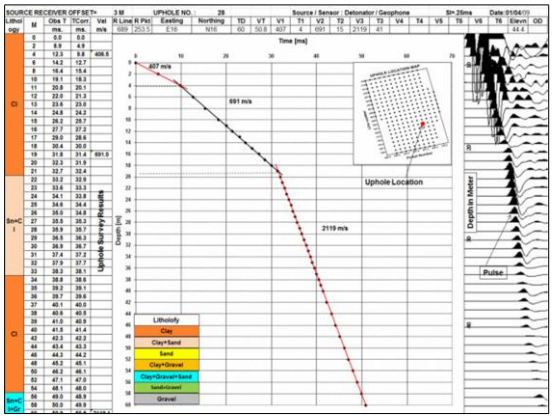

Fig.4- Sample plot of uphole survey

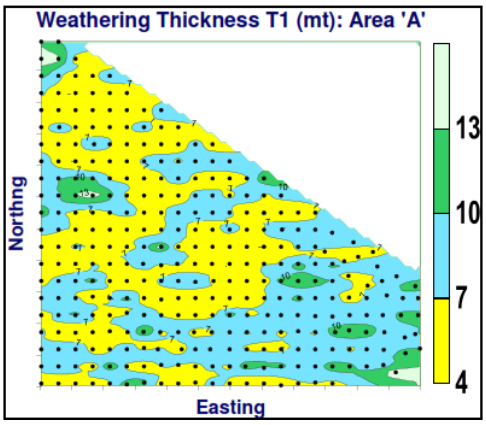

Fig. 5- Weathering Thickness T1 (mt): Area 'A'

Sample of Data Base

SIG	Line no.	Pkt	Easting	Northing	Elevn	TD	VT	V1	T1	V2	T2	V3	T3
A	316	307	E1	N1	36.2	60	50.6	629	6	1862	53	2102	2
A	316	379	E2	N2	37.2	60	45.5	581	7	2357	21	1918	32
A	316	451	E3	N3	35.3	60	42.8	340	4	1821	53	2502	3
A	316	487	E4	N4	35.0	60	51.8	796	5	1200	16	1862	39
A	316	523	E5	N5	36.0	60	48.3	598	7	1832	49	2256	4
A	316	559	E6	N6	34.6	60	52.2	760	8	1487	48	1689	4
A	316	631	E7	N7	34.4	60	49.8	572	6	2126	51	2388	3
A	316	667	E8	N8	31.5	60	38.5	538	4	1799	51	2106	5
A	316	775	E9	N9	29.0	60	41.3	911	5	1818	51	2201	4
A	316	811	E10	N10	27.1	60	41.1	907	7	1810	47	2308	6
A	316	847	E11	N11	29.8	60	46.3	763	5	1476	52	2018	3
A	316	883	E12	N12	29.0	60	45.1	420	6	1601	50	2701	4
A	316	919	E13	N13	27.0	60	41.7	415	4	1843	52	2581	4
B	65	157.5	E14	N14	42.6	60	47.5	501	9	1249	37	1901	14
B	65	205.5	E15	N15	43.8	58	41.6	623	8	1292	37	2017	15
B	65	253.5	E16	N16	42.0	60	40.3	583	11	1447	43	1992	6
B	65	301.5	E17	N17	44.0	60	37.5	439	4	1989	52	2022	4
B	65	349.5	E18	N18	41.1	60	45.2	428	8	1307	20	1977	32
B	65	397.5	E19	N19	44.0	60	41.9	458	9	1618	20	1959	31
B	65	445.5	E20	N20	40.5	60	35.6	612	7	1589	20	1997	33
B	65	493.5	E21	N21	40.1	60	36.9	509	4	2017	53	1802	3
B	65	541.5	E22	N22	38.7	60	41.4	498	6	1956	51	2233	3
B	65	589.5	E23	N23	38.3	60	52.8	532	9	1143	15	1947	36
B	65	637.5	E24	N24	35.8	60	52.6	563	10	1133	43	1953	7
B	65	685.5	E25	N25	35.8	60	48.4	532	9	1056	38	1785	13

Table1- Sample of Data Base

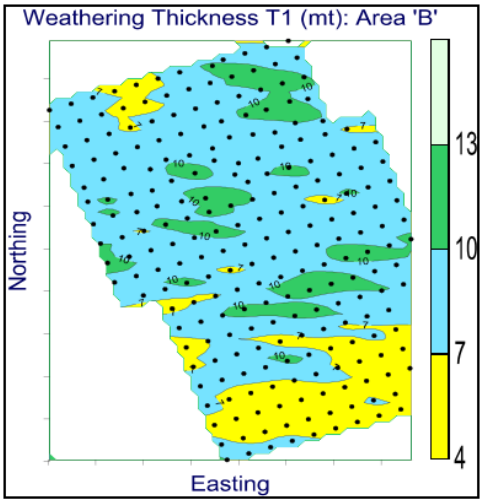

Fig. 6- Weathering Thickness T1 (mt): Area 'B'

SIG	Line no.	Pkt	Easting	Northing	Elevn	TD	VT	V1	T1
A	316	307	E1	N1	36.2	60	50.6	629	6
A	316	379	E2	N2	37.2	60	45.5	581	7
A	316	451	E3	N3	35.3	60	42.8	340	4
A	316	487	E4	N4	35.0	60	51.8	796	5
B	65	157.5	E14	N14	42.6	60	47.5	501	9
B	65	205.5	E15	N15	43.8	60	41.6	623	8
B	65	253.5	E16	N16	42.0	60	40.3	583	11
B	65	301.5	E17	N17	44.0	60	37.5	439	4

Table1a- Zoomed Sample of Data Base

The thickness contour map of sub weathered layer (T1) of area 'A', 'B' and combined are shown below in Fig. 5, 6, & 7 respectively.

The sub-weathering thickness (T1) is varying from 4 to 16 mt in area 'A' (Fig. 5), 4 to 13 mt in area 'B' (Fig. 6), which are reflected in data base and 4 to 16 mt in the area 'C' (Fig. 7).

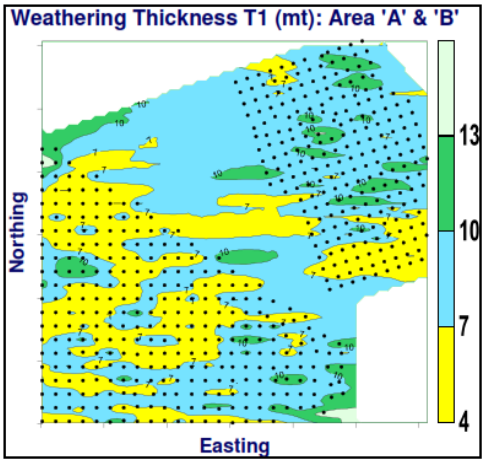

Fig.7- Weathering Thickness T1 (mt): Combined Area

The velocity contour map of sub weathered layer (V1) of area 'A', 'B' and combined are shown below in Fig. 8, 9, & 10 respectively.

The sub-weathering velocity(V1) is varying from 300 to 900 m/s in area 'A' (Fig. 8), 300 to 800 m/s in area 'B', mostly 300 to 700m/s (Fig. 9), which are reflected in data base. It is varying from 300 to 900 m/ s in the area 'C' (Fig.10).

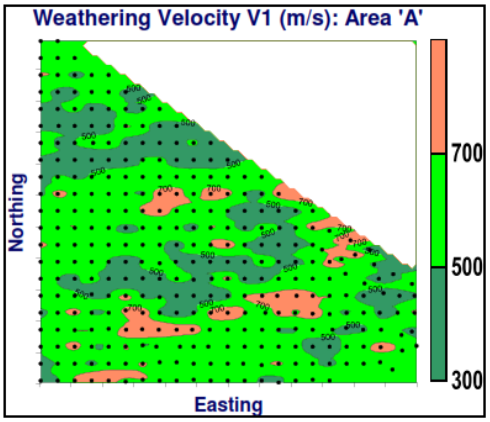

Fig.8- Weathering Velocity V1 (m/s): Area 'A'

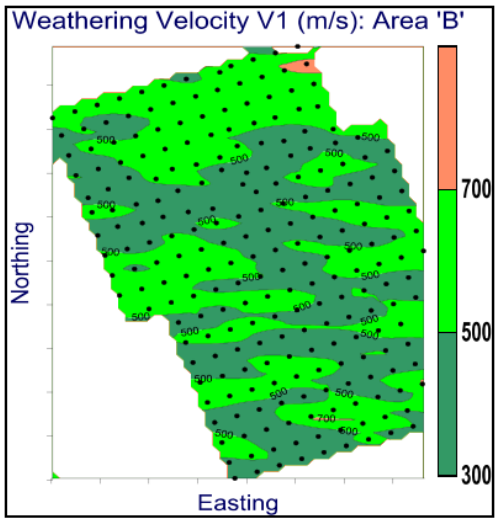

Fig.9- Weathering Velocity V1 (m/s): Area 'B'

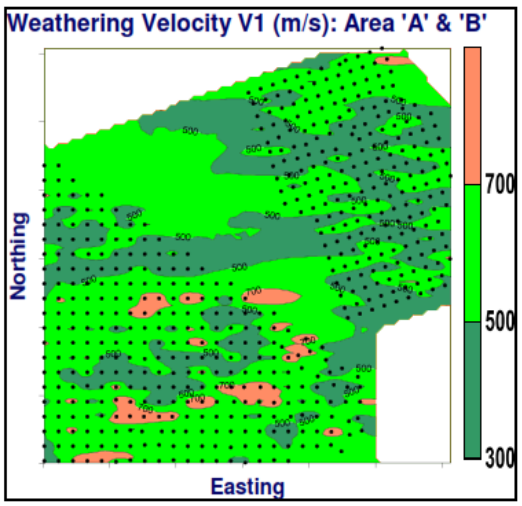

Fig.10- Weathering Velocity V1 (m/s): Combined Area

The thickness contour map of sub weathered layer (T2) of area 'A', 'B' and combined are shown below in Fig. 11, 12 & 13 respectively.

The sub weathering thickness (T2) is varying from 13 to 52mt in area 'A' (Fig. 11) & 12 to 53mt in area 'B' (Fig. 12), which are reflected in data base. It is clear that the thickness (T2) within the area 'C' is varying from 20 to 52mt (Fig. 13).

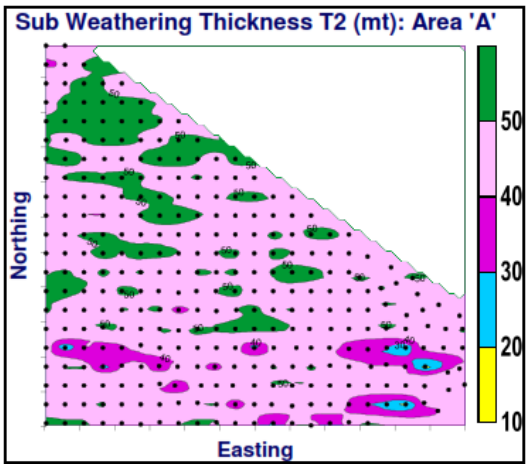

Fig. 11- Sub Weathering Thickness T2 (mt): Area 'A'

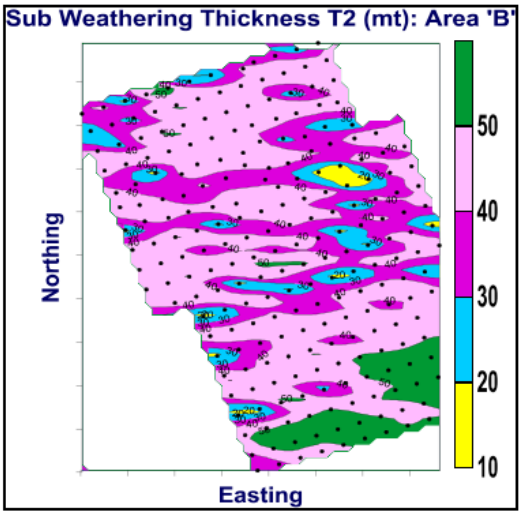

Fig. 12- Sub Weathering Thickness T2 (mt): Area 'B

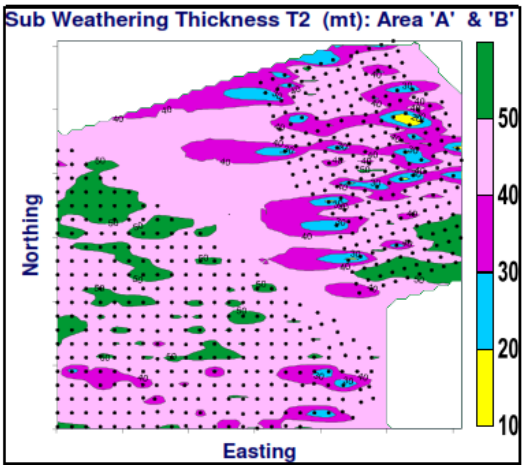

Fig. 13- Sub Weathering Thickness T2 (mt): Combined Area

The velocity contour map of sub weathered layer (V2) of area 'A', 'B' and combined are shown below in Fig. 14, 15, & 16 respectively.

Sub weathering Velocity (V2) is varying from 1200 to 2500 m/s in area 'A'(Fig. 14), 1050 to 2500 m/s in area 'B'(Fig. 15), which are reflected in data base. It is varying from 1050 to 2500 m/s in the area 'C' (Fig. 16).

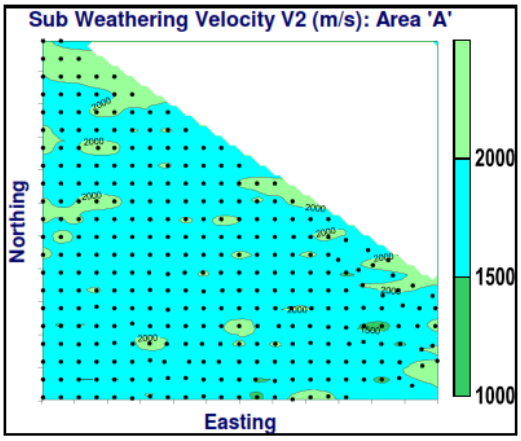

Fig. 14- Sub Weathering Velocity V2 (m/s): Area 'A'

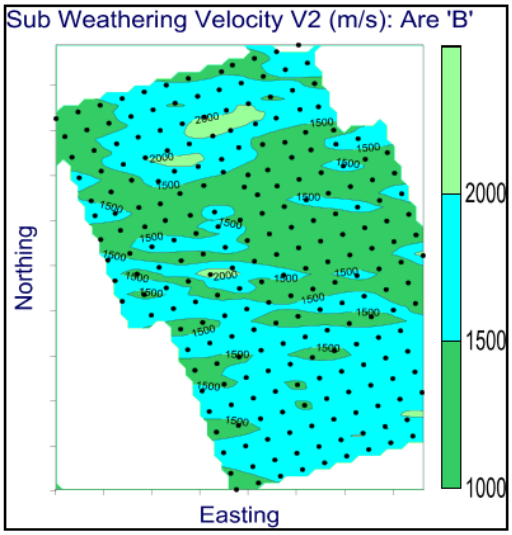

Fig. 15- Sub Weathering Velocity V2 (m/s): Area 'B'

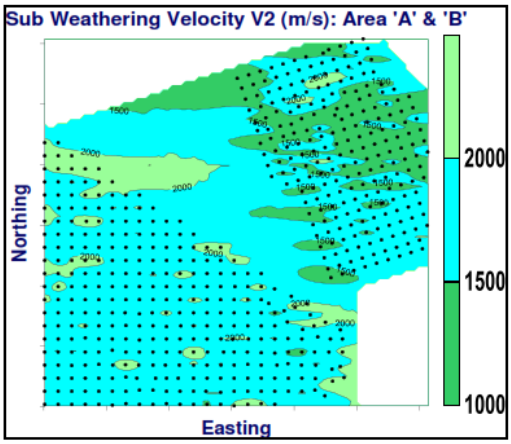

Fig. 16- Sub Weathering Velocity V2 (m/s): Combined Area

In order to have an idea of the best shooting media and its approximate optimum depth for placing the charge within the area 'C', An arbitrary line 'AB' is drawn from location A in area 'A' to location B in area 'B' as shown in Fig. 17 from any uphole location in area 'A' to another uphole location in area 'B', in desired direction. The near surface model (NSM) was generated using the results (V1, T1, V2, T2 etc) which are falling on the selected line. The uphole results, falling on the line, marked as 1, 4, 7, 10, 13, 21 to 31, were taken to get NSM along the line.

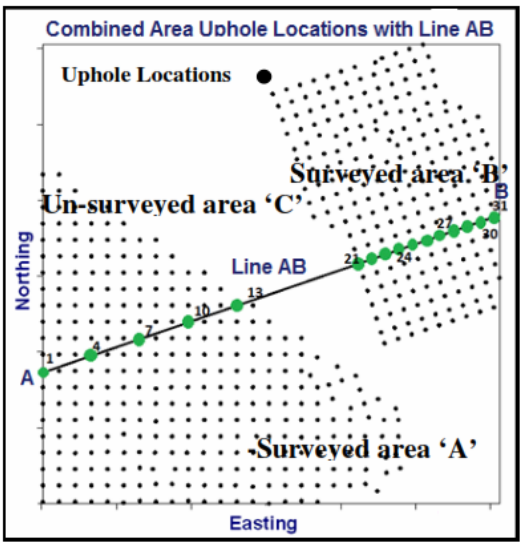

Fig. 17- Uphole Line AB in the Combined Area

The NSM along on the line 'AB' was taken for study, the best shooting zone in terms of velocity in area 'A' (Fig. 18) is 1500-2500 m/s and in Optimum depth is from14 mt to 27 mt. and similarly for the area 'B' (Fig. 19), velocity is 1500-2500 m/s and optimum depth is varying from 16 mt to 34mt below the surface. Fine tuning can be done with the help of lithology and pulse study for both the areas.

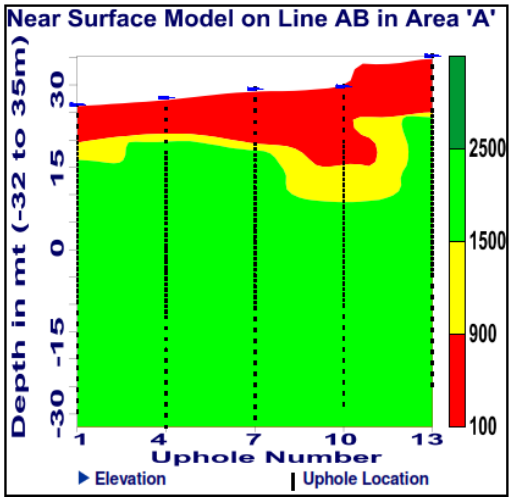

Fig. 18- Near Surface Model along Line AB in Area A

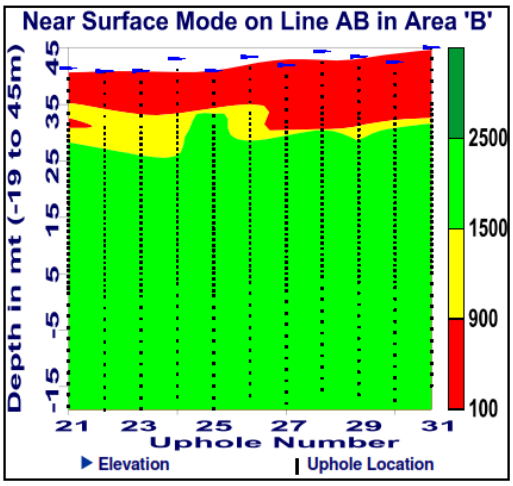

Fig. 19- Near Surface Model along Line AB in Area B

After the study, the combined NSM along the line 'AB' is generated, shown in Fig. 20. The best shooting velocity for the un-surveyed area 'C' is varying from to 1500-2500 m/s and the optimum depth for better seismic energy transmission is varying from 14mt to 20 mt. This shooting depth in the un-surveyed area is also supported from the lithology (Fig. 21, 21a) and pulse shape (Fig. 22, 22a) of the uphole data acquired in area 'A' and 'B'.

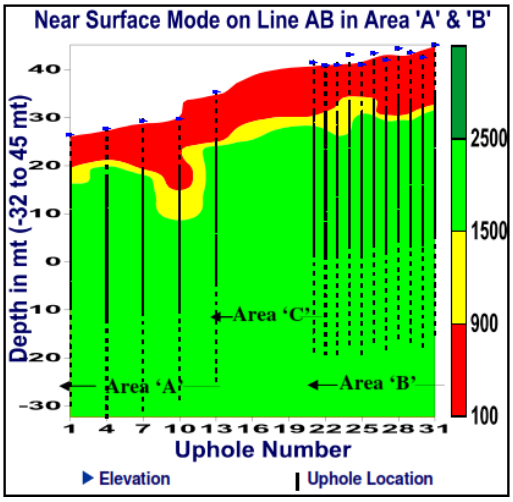

Fig. 20- NSM along Line AB in Combined Area

Lithology of the upholes, Sl No: 1 to 31, falling on the line AB shows in Fig.21 and the zoomed portion is shown in Fig. 21a. For selecting best shooting medium, lithology plays a very important role. Clay and saturated sands with clay contents is showing good pulse (Fig-22) and observed even in seismic data acquisition.

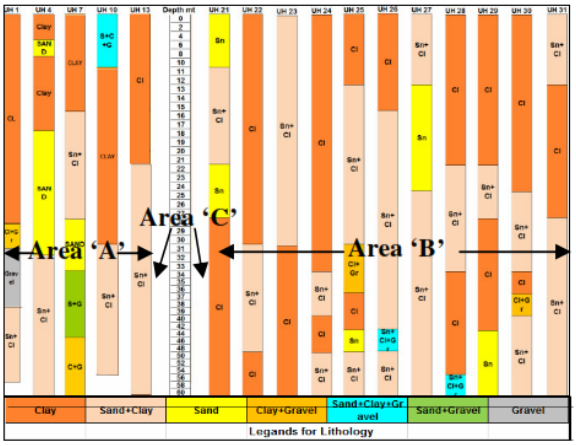

Fig. 21- Lithology of the upholes along line AB

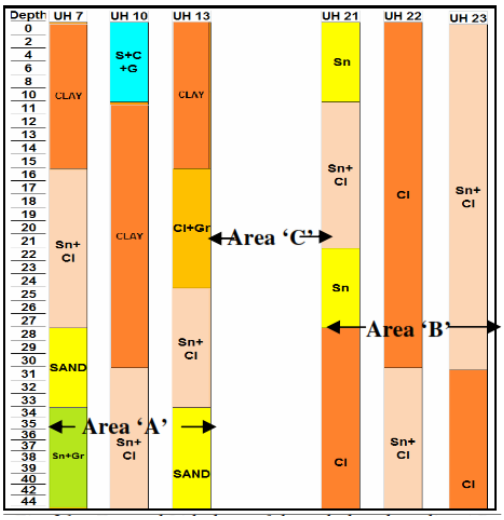

Fig. 21a- Zoomed Lithology of the upholes along line AB

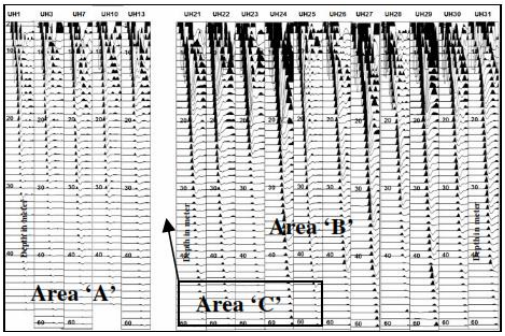

Fig. 22- Pulse of the upholes along line AB

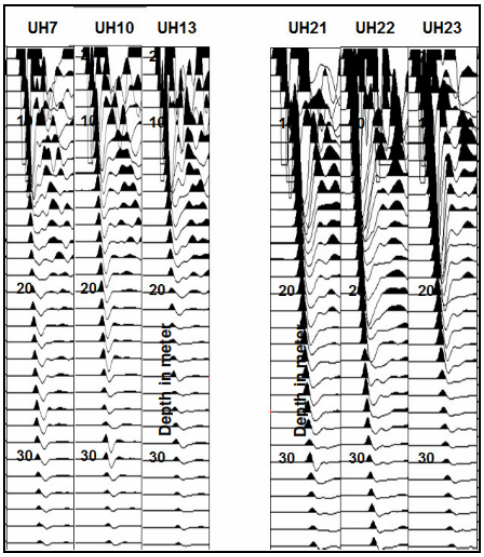

Fig. 22a- Zoomed Pulse of the upholes along line AB

Conclusions

From the study, it is clear that the seismic acquisition crew can get very good idea about the sub surface, with the help of the existing database. The approximate range of various layer thicknesses, velocities and the best shooting media for placing the charges and its optimum depth (OD) can be obtained. The crew can utilize the database, study for an unknown area and plan accordingly in advance to reduce the cost of acquisition. Few uphole can be taken to reconfirm the data which saves lot of acquisition time. This will also help for future planning for the purpose of tendering, cost estimates of the project etc., besides helps in advance planning of the seismic data acquisition.

Acknowledgments

The authors are very grateful to the Basin Manager, WON Basin, ONGC, Vadodara for his cooperation in completing the project. The authors are very much thankful to Shri USD Pandey, GM-HGS, WON Basin Vadodara for his encouragement in publishing this work. Authors are sincerely grateful to Dr Navin Agarwal and Mr U P Singh for their contribution in initiating and creating the data base.

References

Cox, M., 1999, Static corrections for seismic reflection surveys: SEG.

The velocity and depth estimation of near-surface layers for static correction, Jun Cai*, Marvin Decker, Robert Bloor, and David Cunningham, GX Technology.

Near-surface S-wave velocity models from two uphole surveys, Saul Guevara*, and Gary Margrave, CREWES-University of Calgary, William Agudelo and FaustoGomez, Ecopetrol-ICP.

Geophysical seismic reflection and uphole survey Analysis of weathered layer characteristic in the 'Mono' field, NW Niger Delta, Nigeria.