TECHNOECONOMIC ANALYSIS OF 3-D SURVEY DESIGNS

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Abstract

The success of a 3D geometry is a function of achieving required coverage bin attributes for preserving the geological information in seismic signature integrated with project cost. The authors were given a project to recommend a suitable 3D geometry for a strati-structural exploration of Paleozoic & Mesozoic prospects in essentially a pro-desert area of operation.

Four 3D field designs were chosen and a comparative study was carried out considering the factors like technical advantage, coverage bin attributes, productivity and cost. The study revealed that, slant shot line method with 12 receiver lines and 2 arms of 6 vibro points each, is a viable geometry from techno economic consideration for the survey.

INTRODUCTION

A project was given to the authors to recommend a suitable 3D geometry for exploring Paleozoic and Mesozoic prospects in essentially a pro-desert area of operation. The total volume of work was 300 sq. km. approx.

Industry at present is implementing various types of 3D geometries, especially line geometries for regular coverage in relatively larger areas. The line geometries are further classified as i) Parallel ii) Orthogonal cross swath iii) Orthogonal double brick iv) Slant shot line v) Zigzag pattern

Signal preservation, enhancing S/N, deployment of available resources optimally and reduction in project cost are the essential factors for a successful 3D geometry.

Bin attributes i) Fold ii) offset distribution iii) Azimuth play an effective role on various 3D processes with a specific geological objective of exploration. The conclusions from many authors may be summarized as follows

- A uniform fold distribution is a pre requisite for all processes.
- Each bin is to be populated with a good mix of near offset traces, middle offset traces and far offset traces with a uniform variation in offset distribution for good velocity analysis and stack.
- Different schools of thought prevail in industry regarding the choice of azimuthal variation.
- Narrow azimuth patches are better for AVO and DMO purpose.
- Wide azimuth surveys are better for velocity analysis, multiple attenuation, static solutions and a more uniform directional sampling of the subsurface.

GEOLOGICAL OBJECTIVE FOR THE PROPOSED 3D SURVEY

3D survey is focused to delineate strati- structural features at Paleozoic and Mesozoic level expected to occur around a depth of 3000-4500m.

GEOMETRIES CONSIDERED

Initially a large area was considered for carrying out 2-D surveys and the proposed 3-D survey constituted a part of it. Where as, the zone of interest, considering the whole area corresponds to 3000-4500 m. specifically in 3-D area it corresponds to 3500 m.

Four 3- D field designs (details given in Table 1) were considered for carrying out the survey in the area. A comparative study was carried out to select the best suited geometry based on the following factors,

a) Technical analysis
b) Productivity

c) Cost

The 3D field geometries represented in Table-1 are the common ones used in industry. Slant shot swath geometry for 3-D surveys are being adapted in Cambay basin situated in North western part of India. Hence, the slant shot geometry was used for comparison. The field layouts of option I to IV are given in figure 1.

a) TECHNICAL ANALYSIS:

The basic field parameters like receiver interval, receiver line spacing, source and receiver parameters considered are kept same for the field designs compared during the study.

The attributes pertaining to offset distribution, non-redundant offsets, azimuth range and fold for each option were generated. Figures 2 to 5 represent the different attributes for the respective option. Table 2 represents a numerical comparison among total fold, non redundant fold and azimuth range for the options.

Analysis of the data indicates that, the ray paths are different but offsets are common in case of orthogonal field geometry. But in the case of slant shooting geometry, both the ray paths and offsets are different resulting in fairly uniform offset distribution in a bin.

The non-redundant fold is considerably better in option IV. Option III is having wider range of azimuths compared to other options.

c) PRODUCTIVITY:

Considering the average value for sweep time, movement time and work hours based on experience in similar terrains, time schedule for project completion were estimated and represented in Table 3. The productivity is better with option III & IV.

By using double vibrator crew, the movement or dead time can be reduced to the bare minimum and it will enhance the productivity and in turn reducing the survey cost. The deployment of double vibrator crews is feasible in case of slant shot field geometry.

d) COST ESIMATION:

The project cost in respect of each option is estimated using the formula

Cost=(0.94+0.01*C)*(D/2.5)*(0.033*G+0.2)*(5/R+0.9)*(2880/(3600-N)*(S/100)* 13.5/V+0.73)

Where,

C = No. of receiver lines
D= Cable density
G= No. of geophones per array
R= Group interval
N= No. of active channels
S= No. of shots per Sq.Km. (In the original formula, S corresponds to shot lines density & the term S/2.5 was used.)
V= Shot point spacing

Table 4 represents a comparison of normalized cost in respect of the selected field geometries. The normalized cost in respect of option II, III & IV works out to be same and lower in comparison with option I.

CONCLUSIONS:

The analysis of the four 3D designs indicates that the option III & IV (slant shooting) merits attention to option I & II. Moreover in option IV the non-redundant fold is maximum.

Option IV having slant shot line geometry with 2 arms of 6 VPs with 12 receiver lines each is a viable design from techno economic consideration, among the four geometries studied.

ACKNOWLEDGEMENTS:

The authors express their sincere thanks to Oil and Natural Gas Corporation Ltd. for giving the permission to publish this paper.

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Author's statement

This is to certify that, the views reflected in this paper are the views of author and do not necessarily reflect the views of the organization they belong to.

TABLE 1 : 3D FIELD DESIGNS CONSIDERED FOR THE STUDY

GEOMETRY	OPTION I	OPTION II	OPTION III	OPTION IV
TYPE	PARALLEL 12 receiver lines with twelfth line as shot cum receiver line	ORTHOGONAL 12 receiver & shot lines with shots in orthogonal direction	SLANT 12 receiver & shot lines with shots in slant direction	SLANT 12 receiver & shot lines with shots in slant direction
BIN SIZE	25 m.X 50m.	25 m.X50m.	25 m.X50m.	25 m.X50m.
RECEIVER LINES	12	12	12	12
GROUP INTERVAL	50 m.	50 m.	50 m.	50 m.
CHANNELS PER LINE	64	64	64	64
SPREAD LENGTH	3150 m.	3150 m.	3150 m.	3150 m.
TOTAL NO. OF CHANNELS	768	768	768	768
MAX. OFFSET	3383 m.	3383m.	3625 m.	3625 m.
FOLD	8X6	8X6	8 X 6	8 X 6
CROSS LINE ROLL OVER	1	6	6	6
SOURCE PARAMETERS				
SOURCE LINE INTERVAL	100 m.	200 m.	200 m.	200 m.
VP DISTRIBUTION	12 th line as shot cum receiver line	12 shots in orthogonal direction	4 arms of 3 vps each	2 arms of 6 vps each
VP INTERVAL	200 m.	200 m.	200 m.	200 m.
NO. OF VPs PER Sq.Km.	60	36	36	36
TOTAL NO. OF VP REQUIRED TO COMPLETE THE PROJECT	17280	10368	10368	10368

TABLE 2 : NUMERCAL VALUES OF DIFFERENT ATTRIBUTES

	OPTION I	OPTION II	OPTION III	OPTION IV
TOTAL FOLD	48	48	48	48
NON REDUNDANT FOLD	26	28	32	36
AZIMUTH RANGE	-34 TO +27	-70 TO +75	-117 TO +45	-65 TO + 58

TABLE 3 : TIME SCHEDULE FOR COMPLETION OF THE PROJECT

	OPTION I	OPTION II	OPTION III	OPTION IV
Sweep time	150 sec.	150 sec.	150 sec.	150sec.
Movement time	5 min.	5 min.	5 min.	5 min.
No. of VP per hour	8	8	8	8
Total VP in 9 hours	72	72	72	72
No. of days required to complete the project with single vibrator crew	240	144	144	144
No. of days required to complete the project with double vibrator crew	NA	72	72	72

TABLE 4: A COMPARATIVE STUDY OF THE PROJECT COST IN RESPECT OF THE SELECTED FOUR GEOMETRIES.

	OPTION I	OPTION II	OPTION III	OPTION IV
NO. OF RECEIVER LINES	12	12	12	12
CABLE DENSITY	10.9	10.9	10.9	10.9
GEOPHONES PER ARRAY	24	24	24	24
GROUP INTERVAL	50 m.	50 m.	50 m.	50 m.
NO. OF ACTIVE CHANNELS	768	768	768	768
VP PER sq. km.	60	36	36	36
VP SPACING	200 m.	200 m.	200 m.	200 m.
COST	89.24	53.5422	53.5422	53.5422
NORMALISED COST	1	0.6	0.6	0.6

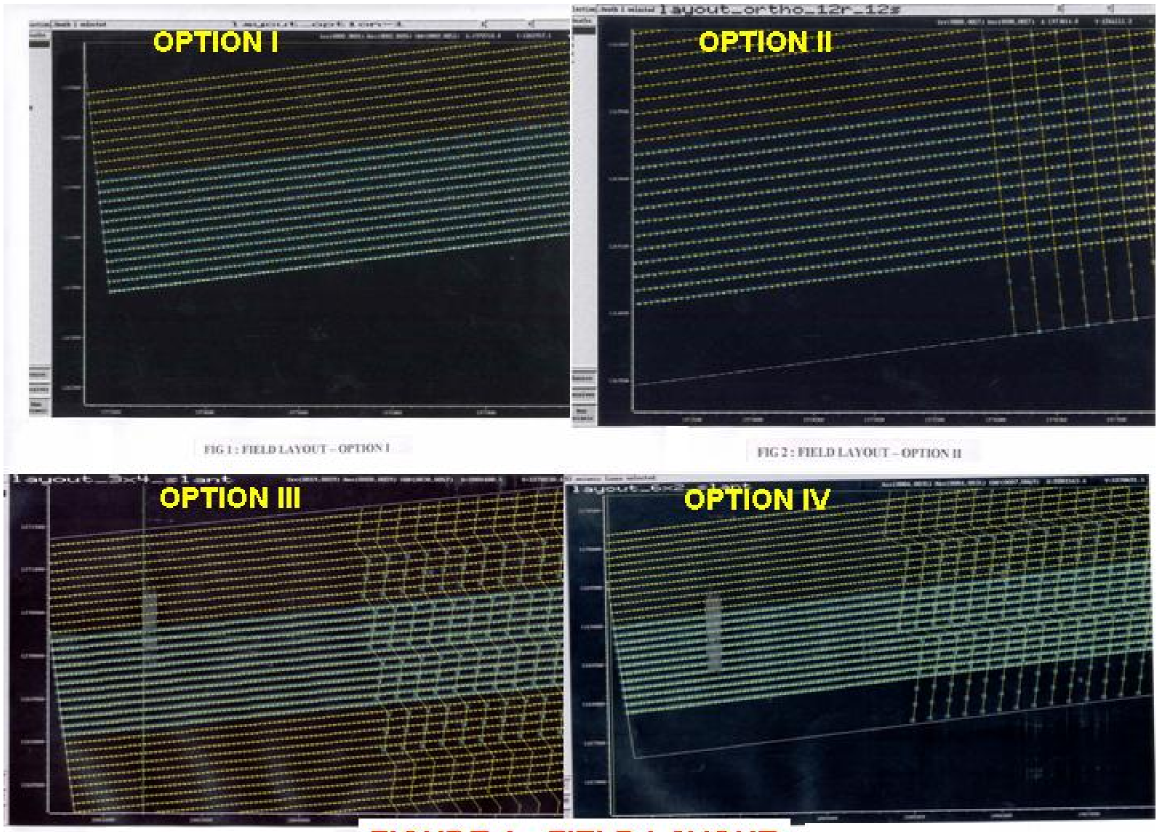

FIGURE 1 : FIELD LAYOUT

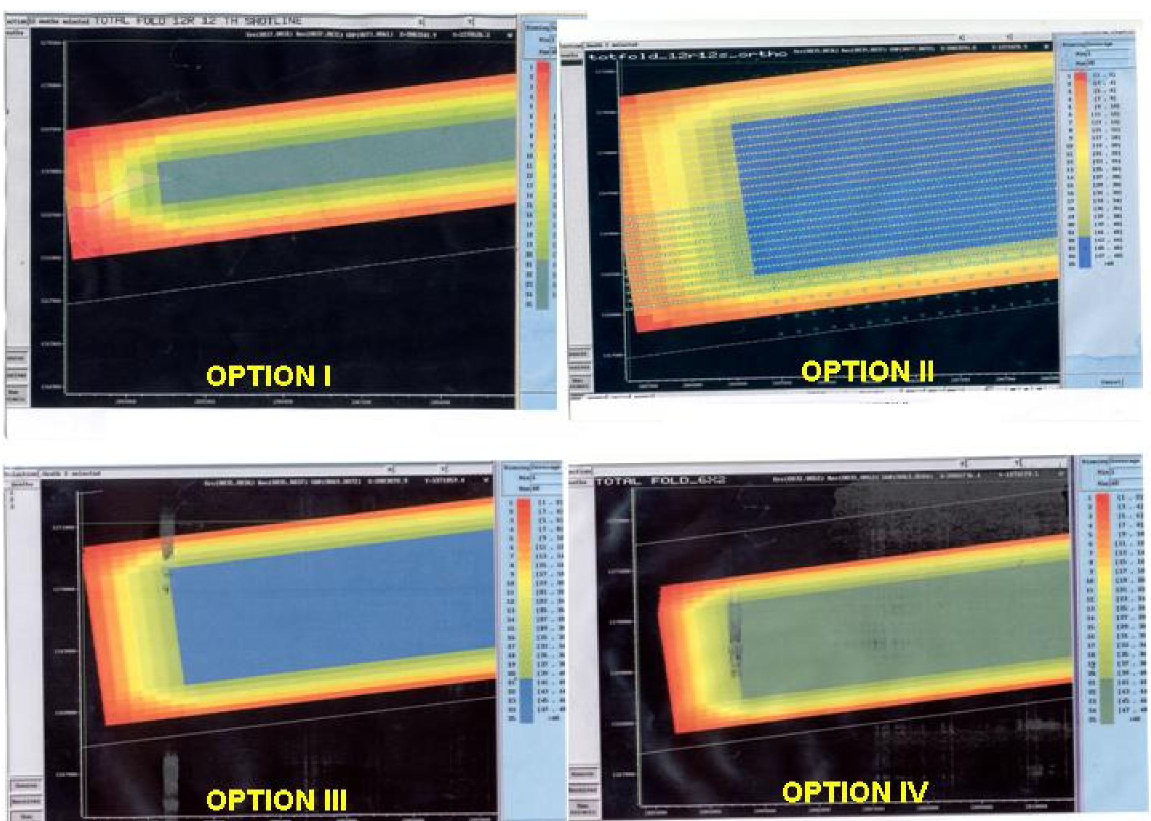

FIGURE 2: TOTAL FOLD IN FOUR OPTIONS

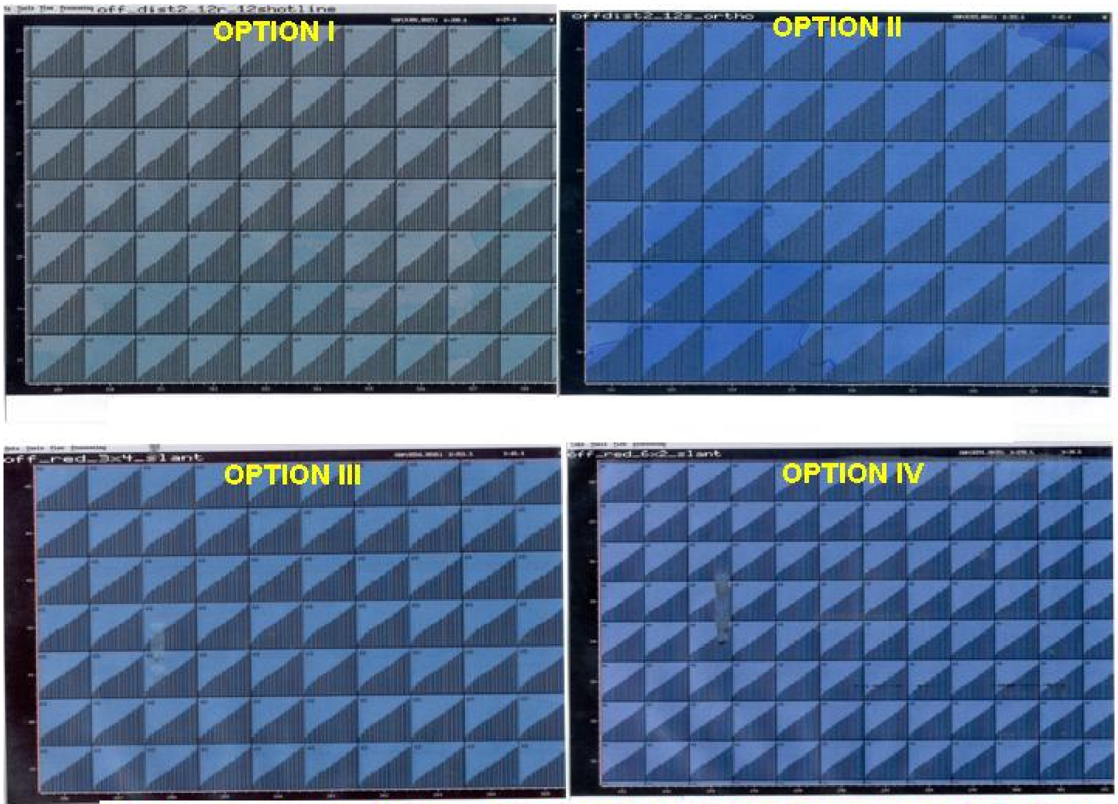

FIGURE 3 : TOTAL OFFSET DISTRIBUTION IN A BIN FOR FOUR OPTIONS

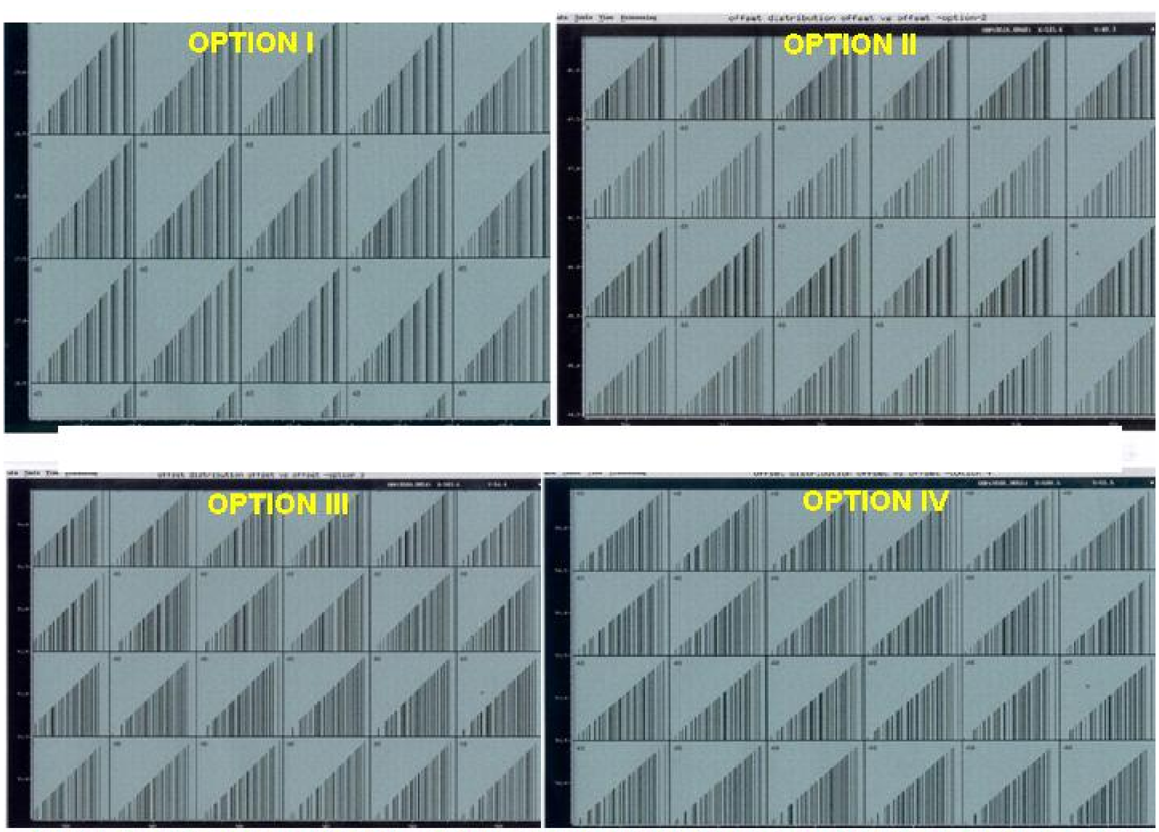

FIGURE 4:NON REDUNDANT OFFSET DISTRIBUTION IN A BIN FOR FOUR OPTIONS

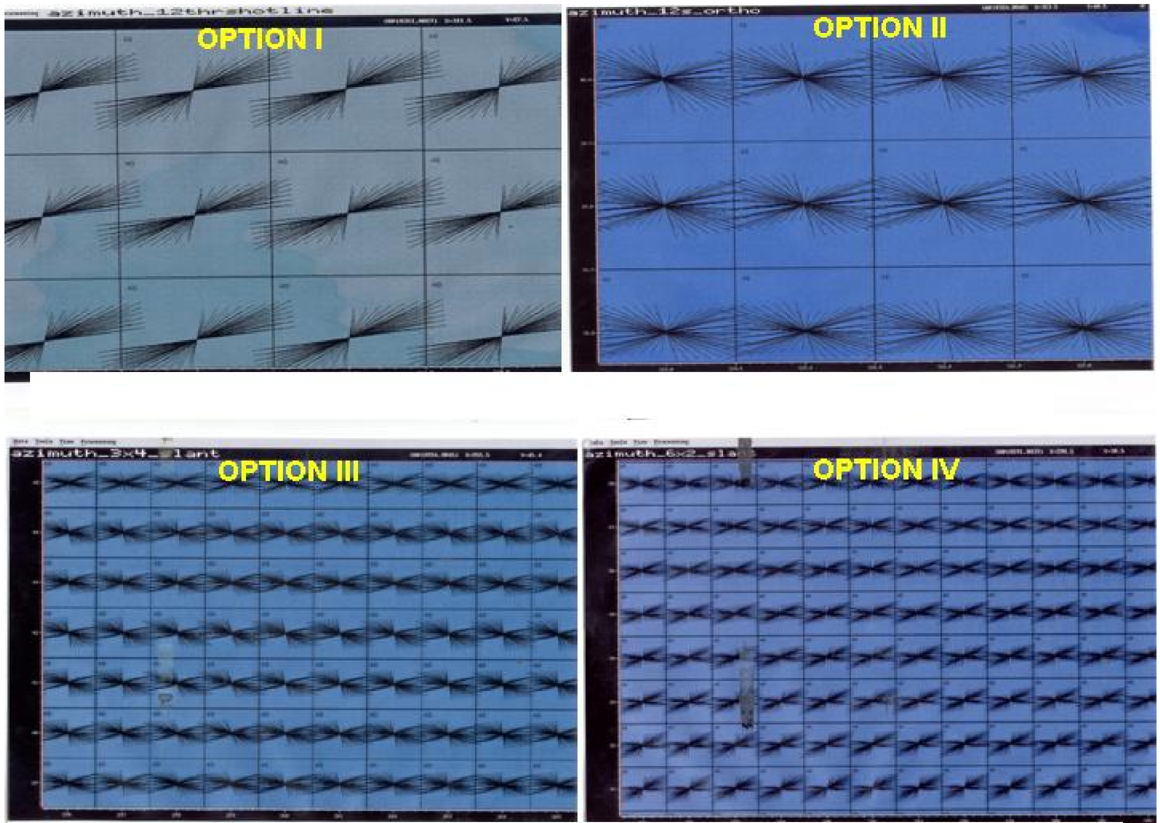

FIGURE 5 : AZIMUTH DISTRIBUTION IN A BIN FOR FOUR OPTIONS