Negotiation with NSO (Non Seismic Object) – 2D Land Seismic Surveys

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Summary

Presence of obstacles characterized by non seismic objects (NSO) in operational areas of 2D and 3D seismic surveys pose practical difficulties in placing source and geophone along the desired location that ultimately leads to loss in desired foldage and source–receiver offsets. However, the above losses can be somewhat minimized if the layout is modified in and around the NSO and compensated for the missing source / geophone. Most common types of NSOs those are encountered along profiles are identified and possible ways to negotiate the same are discussed with reference to 2D land seismic surveys through study of CDP scatter, median line and fold in each case.

Introduction

Non Seismic Objects (NSOs) or obstacles are encountered during seismic surveys (almost everywhere in land surveys), which pose practical difficulties in placement of source or receiver or both along the planned layout. These difficulties vary with the shape and size of the NSO and type of survey (2D/3D). Whatever may be the case i.e. whether it is 2D or 3D; larger or smaller NSO, the ultimate loss due to presence of NSO along the source / receiver line, is the loss of nominal foldage, offset; and smearing of CDPs, if the layout is not modified in accordance with the shape and size of the NSO, to compensate for the missing source / receiver placement within its limit. The loss of above components of data is undesirable and therefore, attempt should be made to keep them as minimum as possible during acquisition stage (Dale G. Stone, 1995). In this work authors have i) visualized and categorized common types of NSOs those are generally encountered in case of land 2D surveys ii) discussed different ways how the source/receiver layout may be modified to negotiate the NSO and iii) studied the resultant CDP scatter, median line and foldage (through binning) of the modified source / receiver layout in and around the NSO for pre-survey planning.

Method

Types of NSO: As a matter of fact NSOs could be broadly categorized into two types i.e.

Type-I: Where shot and receivers both can not be placed inside the NSO; and

Type-II: Where receivers can be placed inside the NSO but shots are prohibited.

Type-I NSO may be characterized by prohibited or restricted areas where any kind of exploration activity is generally not permitted by government e.g. air bases, largescale prawn ponds, military establishments, etc. Whereas, areas like towns, villages, private attached properties, etc. may represent type-II NSOs where shots can be placed outside the safe limit around the NSO. Depending upon the type of NSOs, their shape and size, different combination of layout of shot/receiver is presumed and the attributes of each modified layout has been studied with GEOLAND software and output are displayed.

A sample 2D line as shown in fig.1 with the acquisition parameters listed below has been considered for the above analysis.

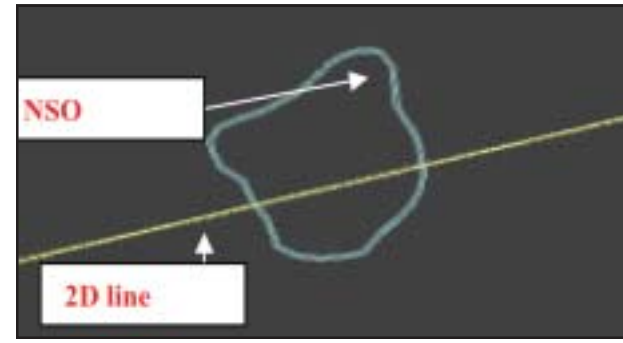

Fig. 1: Desired layout of the 2D line passing through one NSO.

Acquisition parameters of the 2D line

No. of active channels	:	240
Group interval	:	25m.
Shot point interval	:	50m.
NTO	:	125m. (5 G.I.)
Generic spread (Sym Split Spread)	:	120 – 5 – 5 – 120

The above geometry results in a nominal uniform fold of 60 as shown in fig.2. The CDP scatter (with an interval of 12.5m.) occupies positions right on the line as displayed in red dots in fig.3. In other words CDPs lie in the plane of the line as long as it is straight. Offsetting or displacement of either source or receiver in the direction other than along the line gives rise to placement of CDP scatter outside the vertical plane containing source / receiver. CDPs in the zone of displaced source / receiver are distributed over an area and not along the original 2D line orientation. GEOLAND software uses terms like 'median line' and 'binning' etc. 'Median line' may be defined as the best-fit line incorporating spatially distributed CDP scatter and therefore, is the best line for plotting of stacked traces. The term 'binning' is however, used to compute fold considering CDP interval equal to half the receiver interval or as defined by the user.

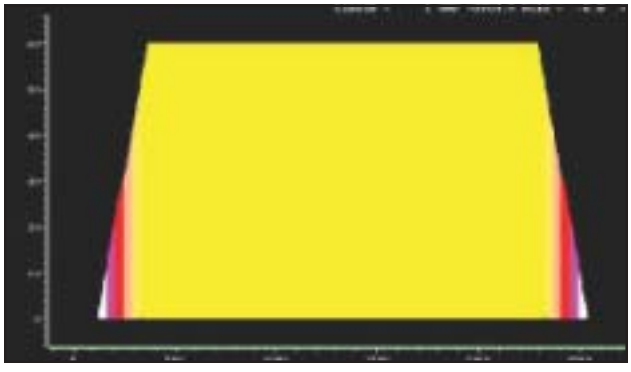

Fig. 2: Normal fold distribution (60) along the 2D line.

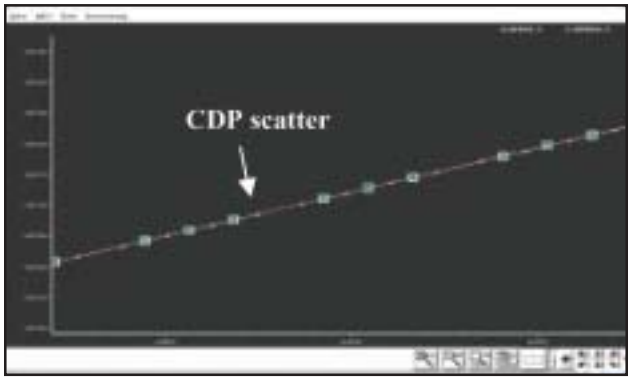

Fig. 3: Normal distribution of CDP scatter (red) along the 2D line.

Negotiation with NSOs

We shall now consider some practical examples of NSO (both type-I and type-II) having dimension of about 400m. X 500m., modification of the layout accordingly to negotiate with the NSO, computation of CDP scatter, median line and resultant fold through binning for studying the effect of the modified layout in and around the NSO.

NSO - Type-I

Option-I: Smooth detouring of the line around one side of the NSO.

The simple option where source and receiver both cannot be placed inside the NSO is to bend the line around the NSO keeping source/receiver interval unchanged (figs.4 & 5). Bending of the line preferably should be to the side of nearer boundary so as to keep loss of offsets to the minimal level. However, allowance for safety distance from the boundary to the shot points has to be kept in mind.

The CDP scatter shown in white along with median line shown in pink in figs.6 & 7. Here the amount of smearing of CDPs is quite evident. The median line has excursion towards the bend of the line around the NSO. The fold distribution computed through binning (fig.8) shows presence of 'fold strips' within the range of detouring with maximum fold of 80 against the normal 60 fold. The computed median line is theoretical one (smoothened). However, same can be edited if required through edit option (fig.9).

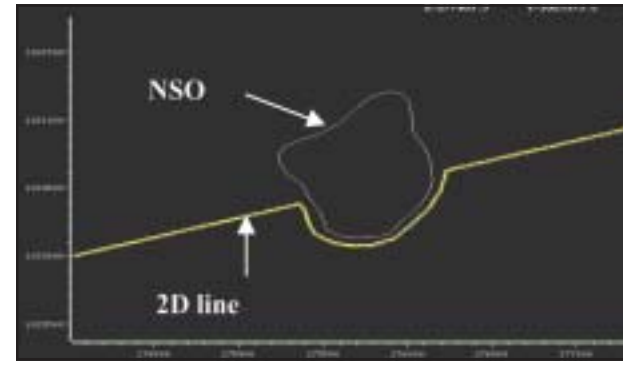

Fig. 4: Smooth detouring of line around NSO (Type-I/ Option-I).

Option-II: Linear shift of the line outside the NSO

This option i.e. shifting both the source and receiver lines outside the NSO in a linear fashion is operation-wise more convenient because it is easier to stake a straight line in field rather than a curvilinear one like in option-I where bearing of the line changes continuously from one point to another. Fig.10 shows such modified layout in the vicinity of the NSO. Two sets of CDP scatter are generated having a linear trend in parallel with the 2D line (fig.11). Median line has also maintained a linear trend

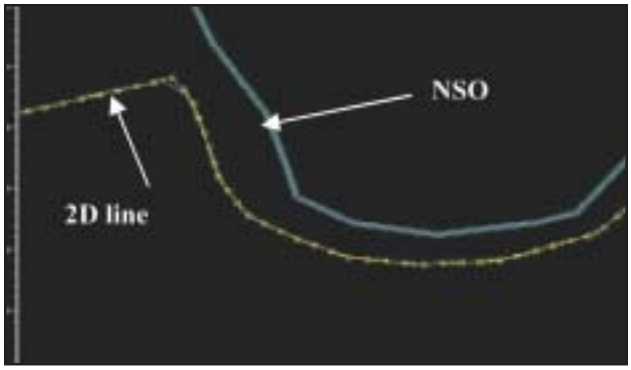

Fig. 5: Smooth detouring of line around NSO (Zoom) (Type-I/ Option-I).

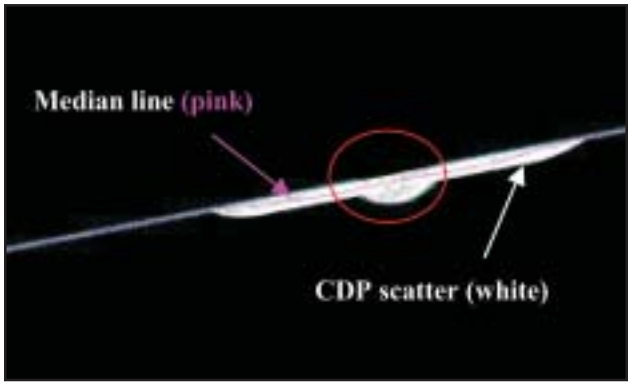

Fig. 6: CDP Scatter (white) and Median line (pink) (Type-I/ Option-I).

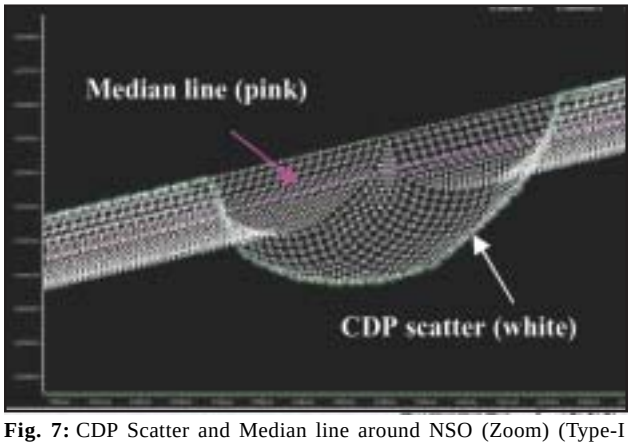

Fig. 7: CDP Scatter and Median line around NSO (Zoom) (Type-I / Option-I).

except in the transition zones (fig.11). Overall variation of fold in the zone in and around the NSO (fig.12) is normal and nearly maintaining the desired nominal 60 fold.

Option-III: Undershooting or broadside shooting across the NSO

This option i.e. undershooting or broadside shooting across the NSO is suitable when the line is passing

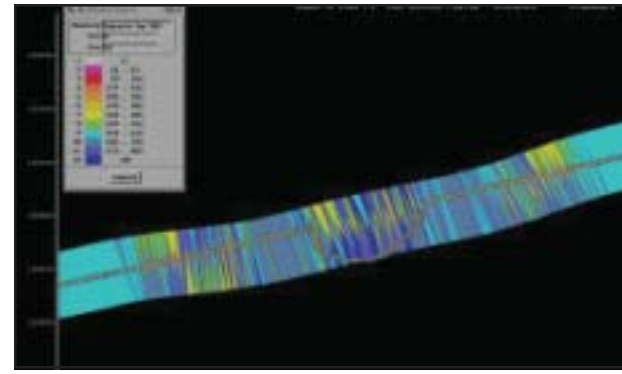

Fig. 8: Fold distribution in and around NSO (Type-I / Option-I).

Control points

	CDP Number	X	Y
1	1	249350.193	1022941.040
2	2	249370.211	1022944.479
3	3	249382.220	1022947.917
4	4	249394.246	1022951.356
5	5	249406.264	1022954.795
6	6	249418.281	1022958.234
7	7	249430.299	1022961.673
8	8	249442.317	1022965.111
9	9	249454.334	1022968.550
10	10	249466.352	1022971.989
11	11	249478.370	1022975.428
12	12	249490.387	1022978.867
13	13	249502.405	1022982.306
14	14	249514.423	1022985.745
15	15	249526.440	1022989.183
16	16	249538.458	1022992.622
17	17	249550.476	1022996.061

Fig. 9: Display of Control points for editing of median line.

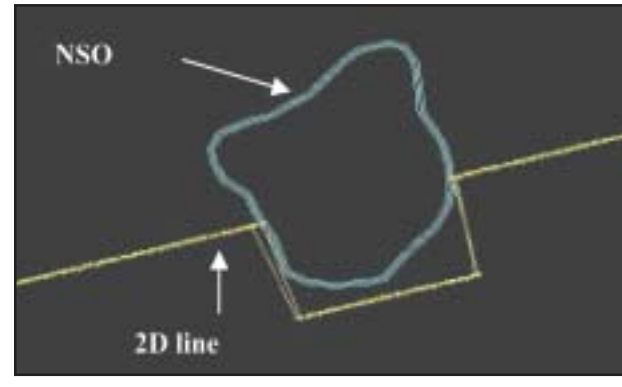

Fig. 10: Linear shift of the line outside the NSO (Type-I/ Option-II).

almost through the middle of the NSO limit (fig.13). Shot and receiver line in this case are shifted beyond the limit of the NSO in opposite direction to each other but by equal distance (fig.13).

This process can be done by selecting shot and receiver lines one after another and shifting them by the desired distance at a time or by drag and drop method when equal shifting of shot/receiver is not warranted and shifting

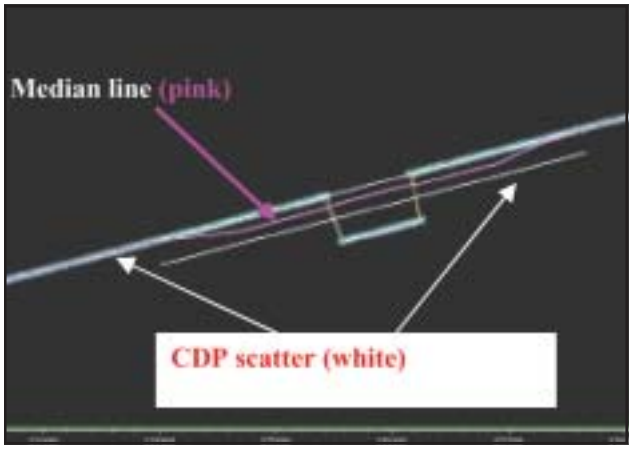

Fig. 11: CDP scatter and median line in and around the NSO (Type-I / Option-II).

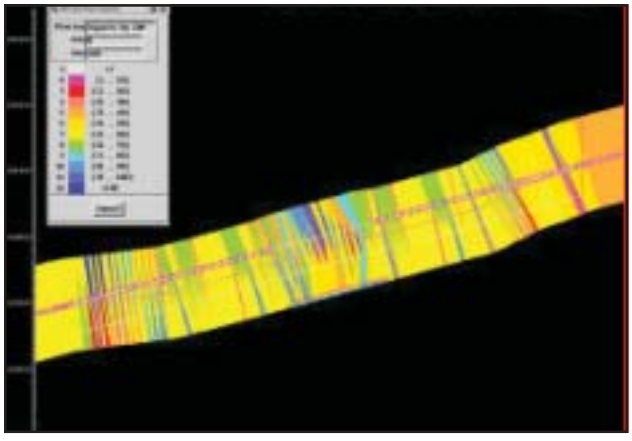

Fig. 12: Fold distribution in around the NSO (Type-I/ Option-II)

is controlled by the shape of the NSO and the position of the line with respect to the NSO. It is seen that four sets of CDP scatters generated are all linear, parallel to the original layout and thus CDP smear is minimum (fig.14). Another interesting feature of this option is that the median line (fig.14) is almost coincident with the original line. The fold distribution (fig.15) also shows less variation and more uniformity in nature.

NSO - Type-II
Option-I: Smooth detouring of the source line only around one side of the NSO

The layout under this option of detouring the source line only without shifting the receiver line is shown in figs.16&17. Same procedure as described in case of option- I for type-I NSO may be followed in this case also for creating the modified source line. CDP scatter (figs.18 & 19) in this case consist of numerous linear CDP lines

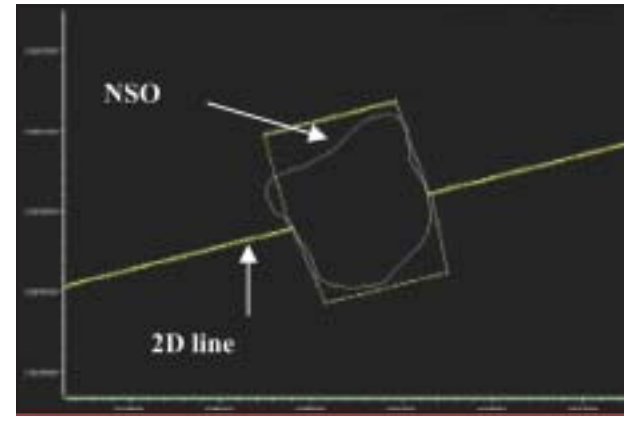

Fig. 13: Undershooting across the NSO (Type-I / Option-III).

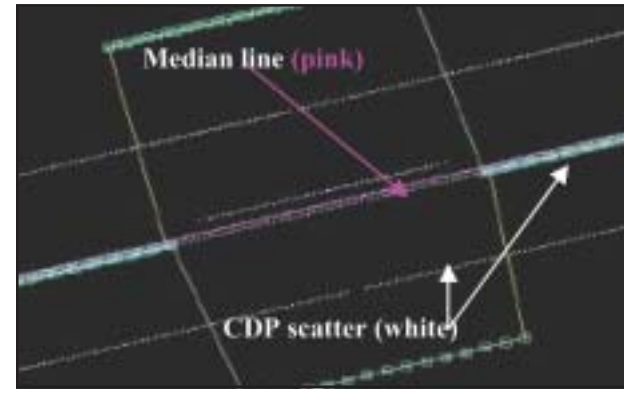

Fig. 14: CDP scatter and median line (pink) in and around the NSO (Type-I / Option-III).

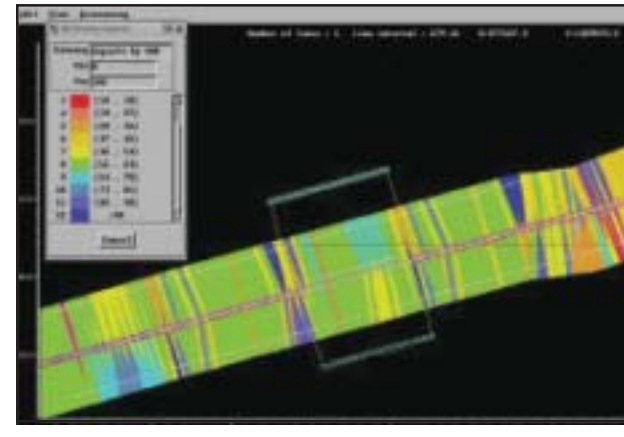

Fig. 15: Fold variation in and around the NSO (Type-I/Option-III).

parallel to the original line orientation. The median line (figs.18 & 19) also follows linear trend and maintains parallel relationship with the original line. Presence of higher fold strips in the fold distribution pattern as shown in figs. 20 & 21 is, however, a drawback of this option. Spread for a particular shot may be viewed along with its display as shown in fig. 22 using view spread option. The spread for a

particular selected (shown as highlighted in the figure) shot will be automatically displayed (and highlighted) once view spread option is utilized.

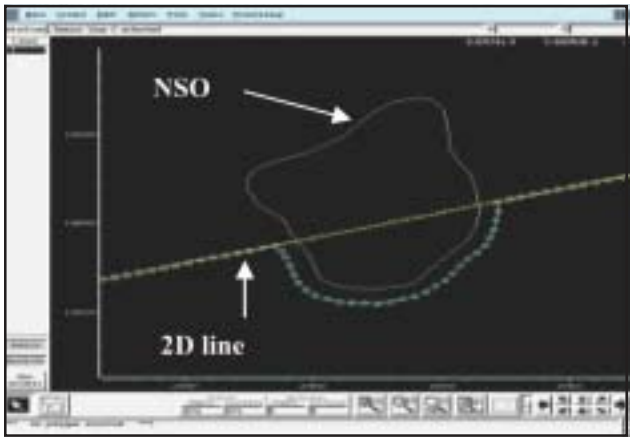

Fig. 16: Layout in case of smooth detouring of source line only around the NSO (Type-II / Option-I).

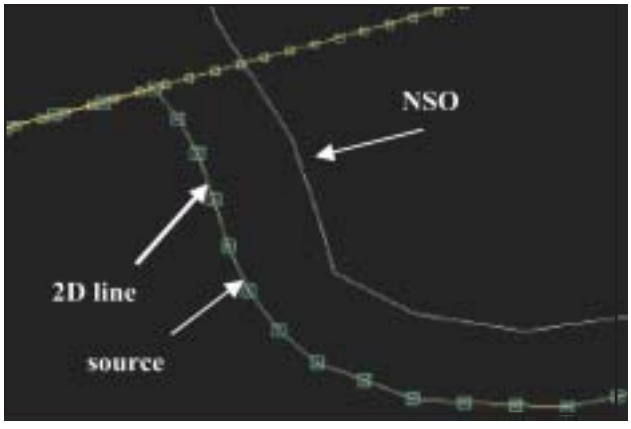

Fig. 17: Layout for Type-II / Option-I) (Zoom).

Option-II : Linear shift of source line outside the NSO

Source line is shifted linearly beyond the outer limit of the NSO as shown in fig.23. Median line (fig.24) shows tendency of excursion towards the line in the vicinity of the NSO although the general trends of the CDP scatter (fig.24) and median lines are almost similar to that of the option-I of type-II. The fold pattern shown in fig.25, however, shows improvement as far as fold strips are concerned. In general, uniformity in fold distribution is seen in and around the NSO.

Conclusions

- Based on practical experience NSO may be broadly classified into two types i.e. where both shots and receivers are to be skipped within the limit of the NSO and another where receivers can be placed but shots falling within the limit of NSO are to be skipped. NSOs of second type are found to be more common.
- Linear shifting of source / receiver or both including undershooting of NSO in land 2D surveys is superior

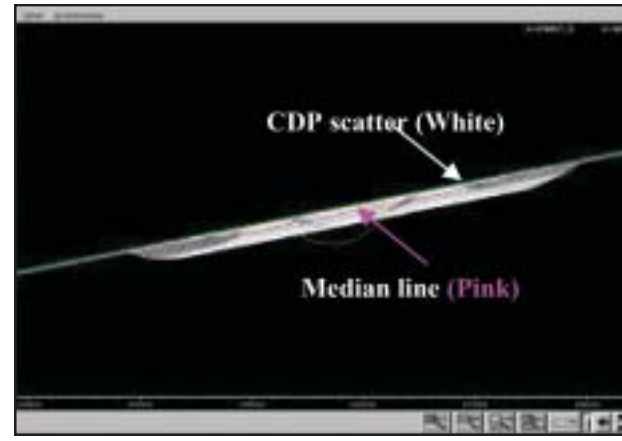

Fig. 18:CDP scatter and median line in and around the NSO (Type-II / Option-I).

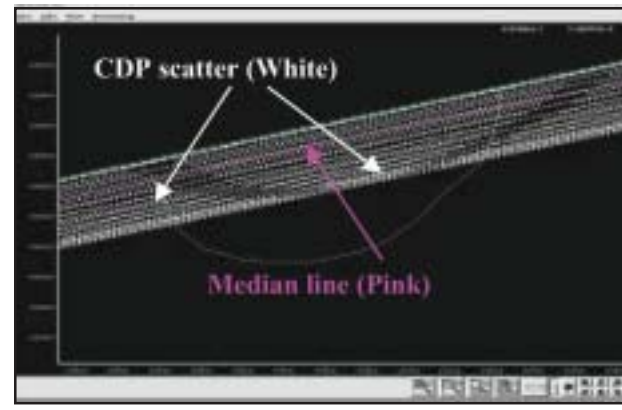

Fig. 19: CDP scatter and median line in and around the NSO (Type-II / Option-I) (zoom).

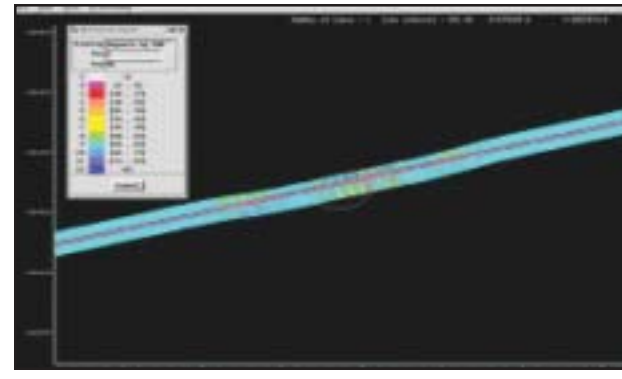

Fig. 20: Fold distribution in and around the NSO (Type-II / Option-I).

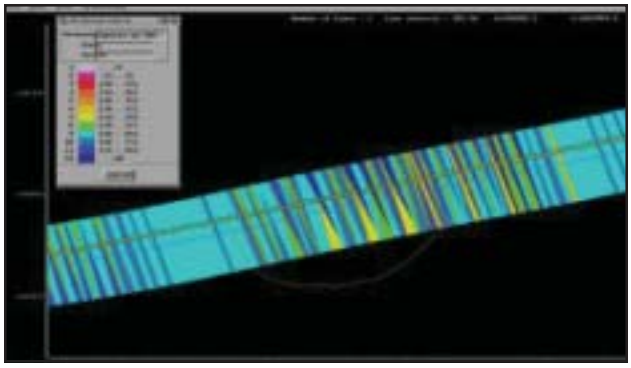

Fig. 21: Fold distribution in and around the NSO (Type-II / Option-I) (zoom).

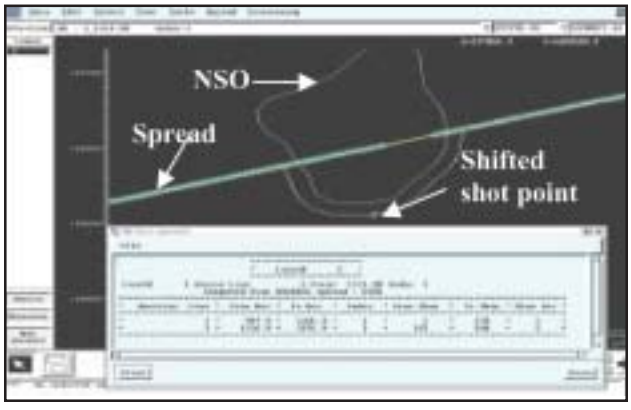

Fig. 22: Viewing spread for shifted source position (Type-II / Option-I).

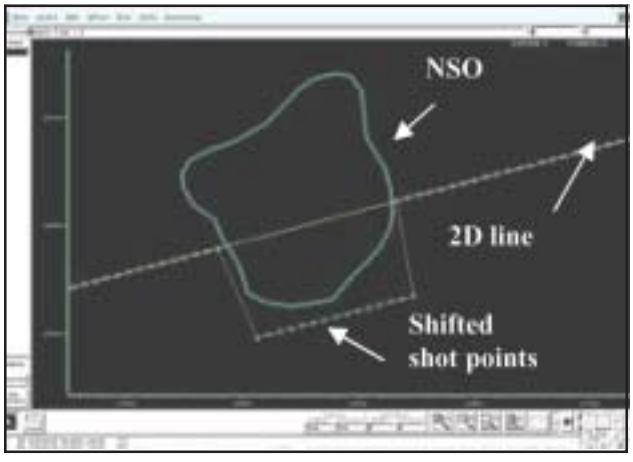

Fig. 23: Layout in case of linear shifting of source line only outside the NSO (Type-II / Option-II).

over smooth detouring of source / receiver or both outside the NSO, as amount of CDP smear and fold variation are more in latter case in addition to operational complications. However, loss of offsets in latter case is minimized.

- Precise knowledge about the type and dimension of

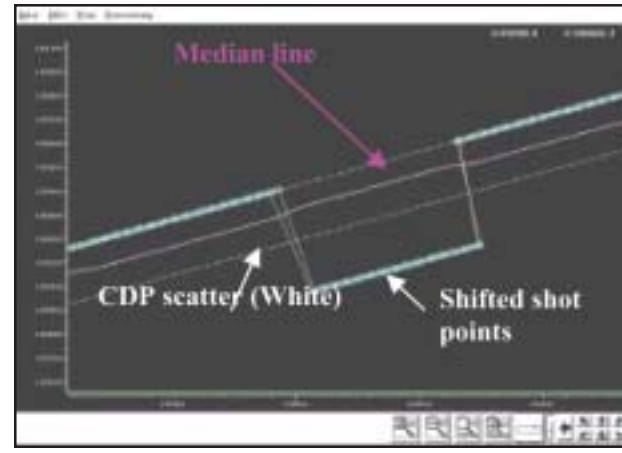

Fig. 24: CDP scatter and median line in and around the NSO (Type-II / Option-II).

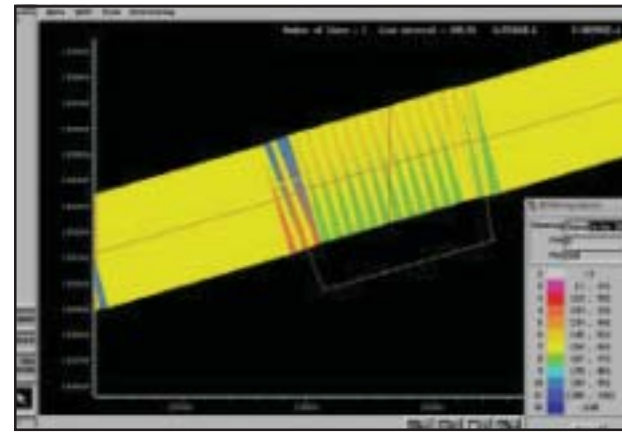

Fig. 25: Fold distribution in and around the NSO (Type-II / Option-II).

NSO and selection of appropriate negotiating technique by optimal utilization of survey design software would greatly add value to the seismic data by minimizing the data gaps loss of foldage and offset.

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

Reference

Dale G. Stone, "Designing seismic surveys in two and three dimensions", SEG Publication, 1995, PP 73 – 84.