“To Move or Not to Move”– The Art of Moving Source Points in a 3-D Survey

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CSEG Geophysics 2002

Introduction

When designing 3-D surveys, fold striping is often introduced when moving source points and receiver locations in areas with restricted access. It is generally accepted to move source points perpendicular to the line direction (offsets) up to some maximum distance instead of moving them in the in-line direction (skids). This paper will show that this practice creates a different fold distribution than is possibly anticipated for many 3-D designs. Improved solutions are presented which hopefully prevent any artificial anomalies, which may be caused due to an unnecessary bin-to-bin fold variation. The comments in this paper are made on the basis of unstructured geology; in structured areas the changes, which are introduced by moving source points, do affect neighboring bins in a simliar manner. Stacked traces encompass the summation of responses within an area of the Fresnel zone. The contribution to the fold in a bin really has a Gaussian distribution, covering a much larger area than a single bin. Migration will collapse those responses into an area on the order of a bin size.

Midpoint Coverage

The energy emitted by a single source point will be recorded by a grouping of receiver locations (spread); hence as many midpoints as there are receiver stations will be recorded. These midpoints fall along lines parallel to the receiver lines and the midpoint lines are half as long as the receiver lines. Moving a source point moves the midpoints by half the source movement (in the direction of the source movement). When recording an entire rack (all source points between two adjacent receiver lines), a contiguous area of simple fold midpoint coverage in the subsurface is achieved, its area being one quarter of the surface area of the receiver patch.

Uniform vs. Non-Uniform Swath

When shooting with uniform swaths the receiver patch location is constant for all source points in a rack (Marine streamer acquisition is an example). A source point move shifts the midpoint location by one-half of the source point move (and in the same direction).

A non-uniform swath moves the receiver patch parallel to the source point progression, even within a rack. When shooting with non-uniform swaths a source point move shifts the midpoint locations by the same amount as the source point move (and in the same direction).

Source Moves perpendicular to the Source Lines

Commonly source points are moved perpendicular to the source line direction (offsets) up to some maximum, e.g. half the line spacing. This may be acceptable for some 3-D designs, e.g. orthogonal. Only a few bins at the edges of the midpoint area are affected with a change in fold. Source moves parallel to the source lines cause entire midpoint lines to fall on the same midpoints as for another source point and therefore duplicate the fold – something that should be avoided at all costs.

Non-Orthogonal (Slant) Surveys

For non-orthogonal (slant) surveys source points are spread out further along the source lines than on orthogonal surveys in order for the midpoints to still fall on to a regular grid (Cordsen et al, 2000). Failing this, the midpoints are going to fall on to unintended locations and may cause severe fluctuations in the fold and offset distributions.

Following the common practice of moving source points perpendicular to the source line direction can cause severe and undesirable fold variations (Fig. 1). These should be avoided at all costs. A far better definition would be to move the source points parallel to the receiver lines. Then the midpoints still fall on to the original midpoint lines; they will merely be shifted in the receiver line direction.

Moving the Receiver Patch

It has been demonstrated, earlier in this presentation, that a source move (while utilizing the uniform swath method) results in a midpoint move of half of the distance of the source move. If the patch were shifted by the same amount and in the direction of the source move, the midpoints are shifted by 100% of the source move. However, if the recording patch were shifted in the opposite direction of the source move (by the same amount as the source move) the fold does not suffer at all. It retains an even fold distribution and the midpoint areal coverage remains constant (Figures 2, 3a and 3b). This holds true for orthogonal or non-orthogonal (slant) surveys. The practice has been deemed undesirable from an operational point of view (Donze & Crews, 2000). However, if one plans the source moves and the acquisition sequence carefully, it might be very practical. Namely, the source points should preferably be moved opposite to the progress direction of the seismic crew; then the receiver patch can easily be moved in the progress direction of the seismic crew. The layout crew will merely lay out ahead of the shooting position and no duplication of field effort is required. Therefore, the observer needs to be aware of such receiver patch shifts and ensure that the layout crew has covered the required areas.

“Random 3-D Surveys”

More often than not, when obstacles are encountered in the field, receiver lines can still be placed as planned. However, source points have to be moved. Frequently, this results in a source geometry that is almost unrecognizable from the theoretical layout. Careful planning of the source moves and the accompanying receiver patch locations should allow one to achieve an even fold distribution. Assuming that the source points have to be moved anyway, the near offset distribution will be as good as one can obtain and the far offset distribution will have some minor modification due to the movement of the receiver patch in the opposite direction of the source movements.

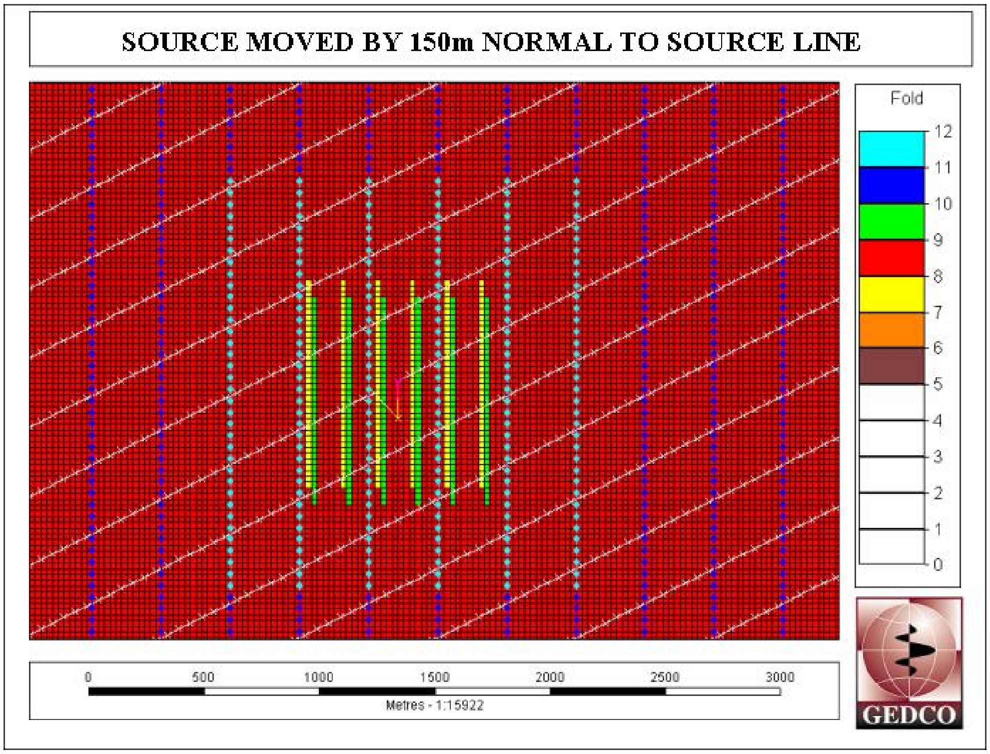


Figure 1 - Fold distribution for source point moves perpendicular to the source line direction

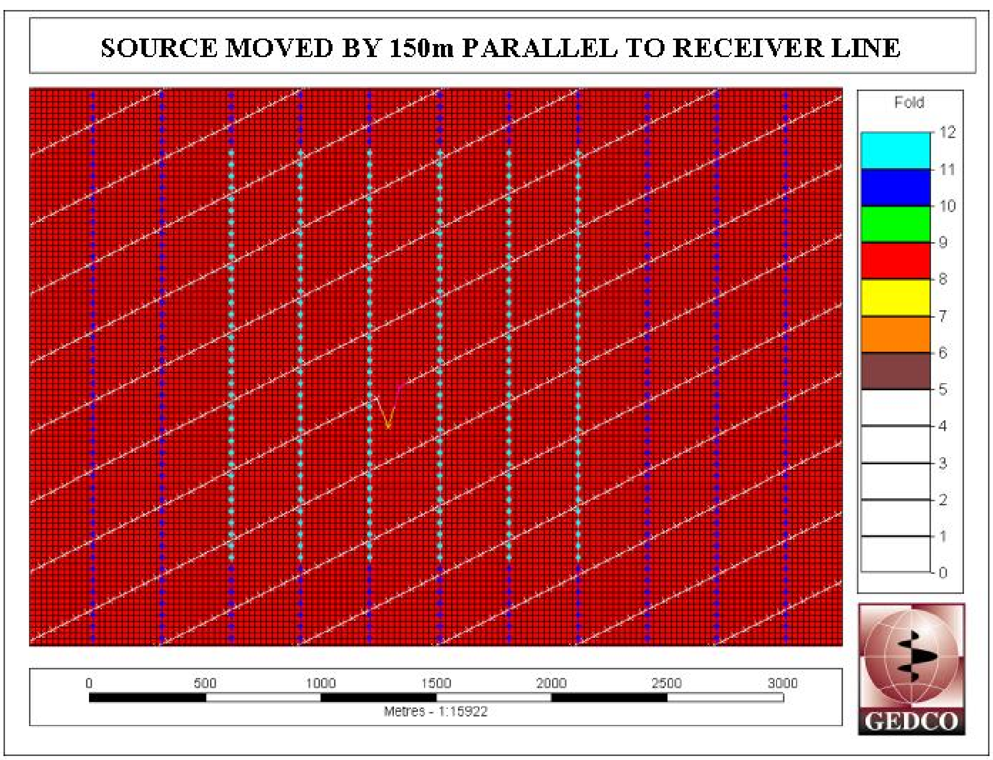
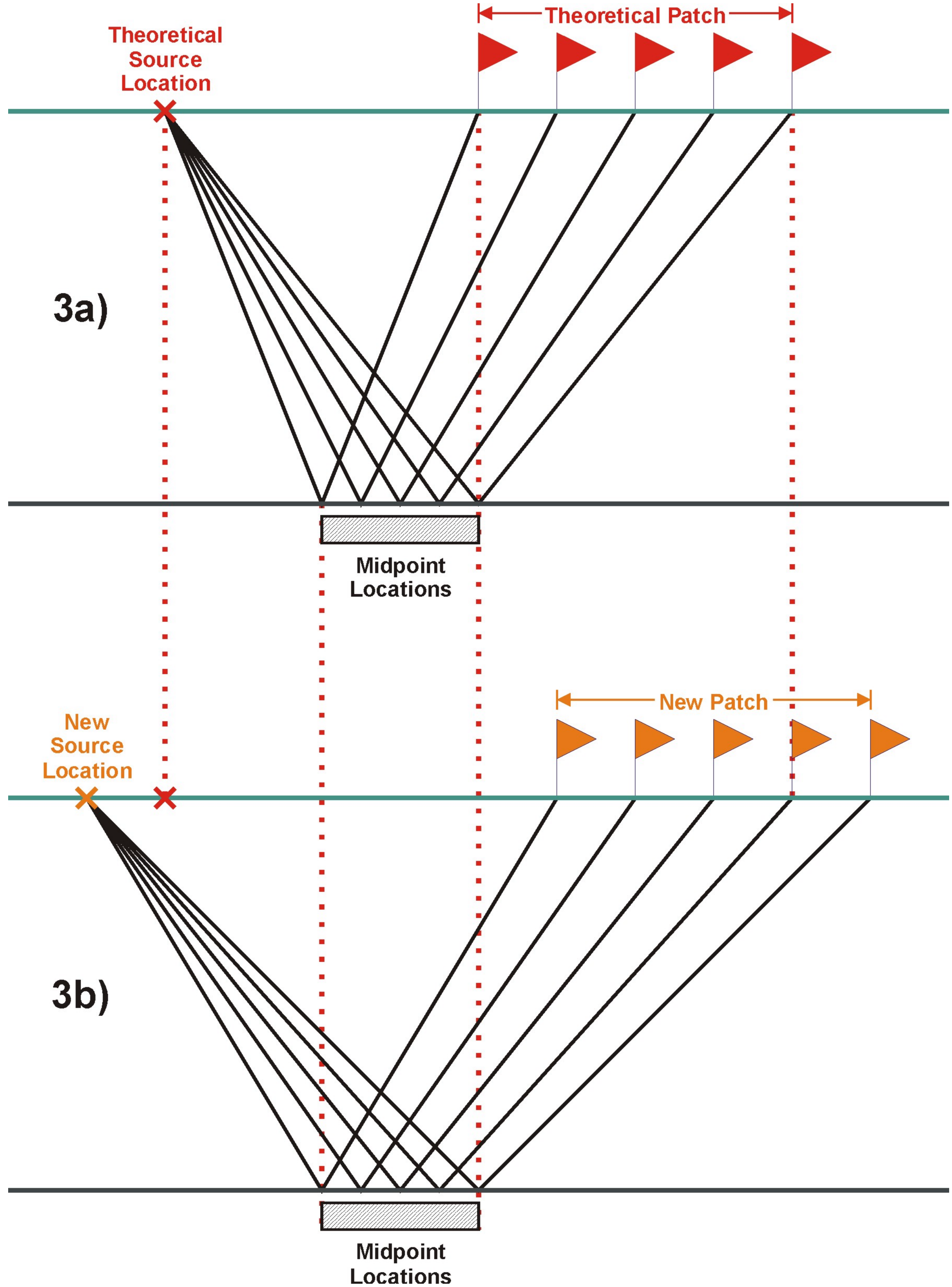


Figure 2 - Fold distribution for source point moves parallel to the receiver line direction coupled with a shift of the receiver patch in the opposite direction



Figures 3a and 3b - Shift of the receiver patch a) without source point move and b) with source point move and a corresponding receiver patch movement in the opposite direction.

Structured Areas

For structural prospects most exploration companies prefer to sample finer in the dip direction than in the strike direction. Hence, it is common practice to have the receiver line direction parallel to the dip direction. How would any source point moves according to the above criteria be affected in such a situation? These and other questions will be answered in the presentation.

Conclusions

The historical practice of moving source points perpendicular to the source line direction is only acceptable for certain designs, e.g. orthogonal. This paper has proven that this practice creates a different fold distribution than is possibly anticipated for many other 3-D designs, e.g. non-orthogonal. The more appropriate definition of moving source points parallel to the receiver line direction coupled with a movement of the receiver patch in the opposite direction (by the same amount as the source move) will, hopefully, prevent any artificial anomalies, which may otherwise be caused by an unnecessary bin-to-bin fold variation.

References

Cordsen, A., Galbraith, M., Peirce, J., 2000, Planning land 3-D seismic surveys: Geophysical Developments No. 9, Soc. Expl. Geoph., 204pp.

Donze, T.W., Crews, J., 2000, Moving shots on a 3-D seismic survey: The good, the bad, and the ugly (or How to shoot seismic without shooting yourself in the foot!), The Leading Edge, **19**, 480-483.