1-51

3D PRESTACK MIGRATION WITH CROSS-SPREADS

GIJS J.O. VERMEER[1] and JORIS L.T. GRIMBERGEN[2]
[1] 3DSymSam - Geophysical Advice, Maduroweg 3, 2252 TS Voorschoten, The Netherlands
[2] Shell International Exploration and Production bv

Introduction

Data acquired with parallel geometry can be described as a collection of common-offset gathers. Prestack migration of such data can be conveniently considered as the repeated application of the migration process to all common-offset gathers. In contrast, data acquired with orthogonal geometry in land or OBC surveys do not allow the construction of common-offset gathers. Instead, the data of an orthogonal geometry 3D survey can be described as a collection of cross-spreads. Each cross-spread has illuminated its own little part of the subsurface which can be imaged by migration. This paper introduces some of the problems associated with migration of cross-spreads.

Cross-spread

A cross-spread is the collection of all traces that have a shotline and a receiver line in common. The total data set of an orthogonal geometry contains as many cross-spreads as there are intersections between shot and receiver lines. Each cross-spread is a single-fold 3D dataset. Its midpoint area is bounded by the shots with the largest offsets from the receiver line and by the receivers with the largest offsets from the shotline. Total fold in any point is made up by as many overlapping midpoint areas of cross-spreads. To create a survey with constant total fold, it is necessary that tilings can be made of cross-spreads with adjacent midpoint areas: where one cross-spread stops, the next one takes over.

Illumination with cross-spreads

There is a one-to-one relationship between the midpoint area of a cross-spread and the area on a reflecting surface that has been illuminated by the cross-spread. The boundary of the illumination area corresponds to the boundary of the midpoint area. For horizontal reflectors, adjacent midpoint areas lead to adjacent illumination areas, but for dipping or curved reflectors adjacent cross-spreads may produce partially overlapping illumination areas as well as holes in the illumination (Fig. 1).

Imaging with cross-spreads (Fig. 2)

In migration, the data contributing to an output point are collected by computing the diffraction traveltime on each trace contributing to the output point. In a cross-spread, the collection of diffraction traveltimes forms a diffraction traveltime surface. The image point is located where this surface is tangential to the reflection traveltime surface of the cross-spread. The image point forms the point of stationary phase in the Kirchhoff migration integral. The reflection times are converted to a depth surface in the output point. The depth values that do not differ more than the length (in depth units) of the wavelet from the depth in the image point contribute to the signal in the output point. Traces outside this zone of influence (Brühl et al., 1996) should cancel each other. (With different figures this description would just as well apply to common-offset gathers.)

Edge effects

The limited extent of a cross-spread has negative effects on the migration result. First, the point of stationary phase may lie too close to the edge of the cross-spread, so that the zone of influence is not complete, leading to amplitude and phase errors (see Fig. 3). A second problem is formed by the truncation of the data outside the zone of influence: here the edge effect prevents full cancellation, leading to migration noise above the event being imaged.

Reduction of edge effects

With tapering of the edges the migration noise above the event can be prevented, however, tapering would also affect the amplitude and phase of the data that was originally not affected. Another reduction of edge effects is possible by the interference effects of adjacent cross-spreads. This is demonstrated in

Fig. 4 for a horizontal event. The edge effects would be more serious for dipping events. Fig. 5 illustrates what happens to the migrated reflection traveltime surface across cross-spread boundaries.

Conclusions

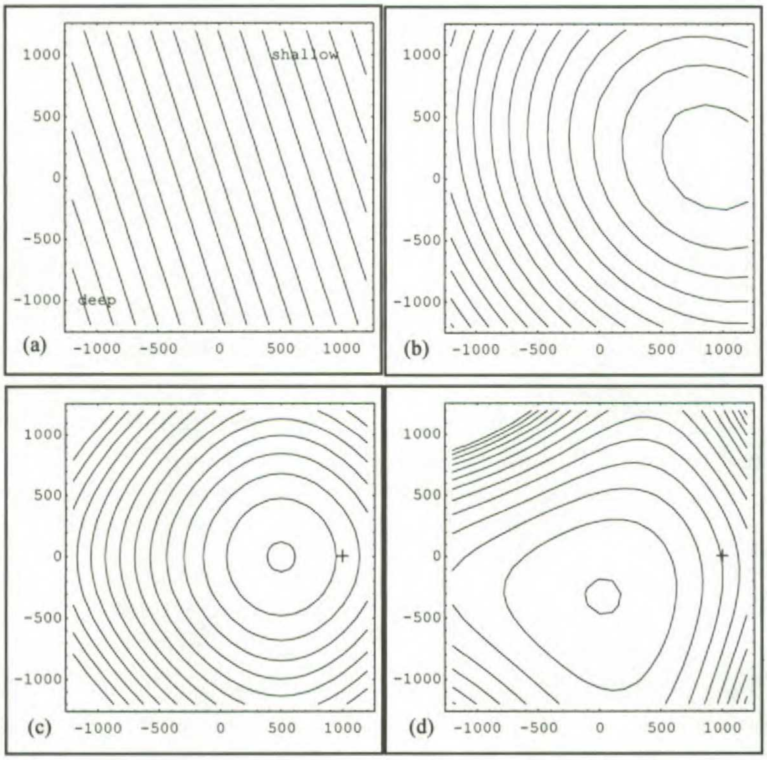
Conventional techniques for prestack migration techniques need to be modified for geometries such as the orthogonal geometry in which proper common-offset gathers cannot be constructed. With the orthogonal geometry edge effects also occur inside the survey boundaries, and need serious consideration. Velocity model updating also requires new approaches. For optimum imaging results, regularity of the basic subsets is of paramount importance.

Acknowledgements

We would like to thank Shell International Exploration and Production B.V. for permission to publish this work.

References

Brühl, M., Vermeer, G.J.O., and Kiehn, M., Fresnel zones for broadband data: Geophysics, **61**, 600-604.



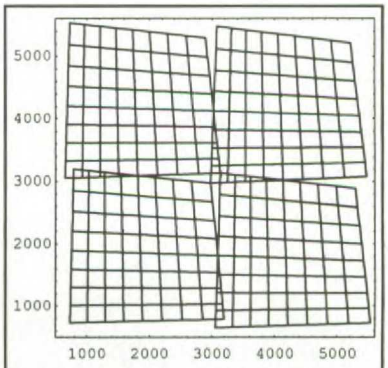


Fig. 1 Illumination of reflector with 15• dip by four adjacent cross-spreads.

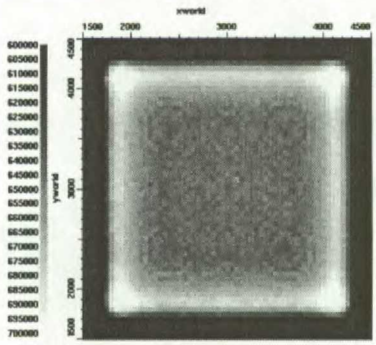


Fig. 2 Contour plots of dipping event for midpoint area of cross-spread. (a) reflector depth, (b) reflection traveltimes, (c) diffraction traveltimes for point on reflector at +, (d) reflection traveltimes converted to depth for output point at +. The image point is at the apex of this surface.

Fig. 3 Single-cross-spread migration. Amplitude of horizontal event. Note strip of high (white) amplitudes around edges.

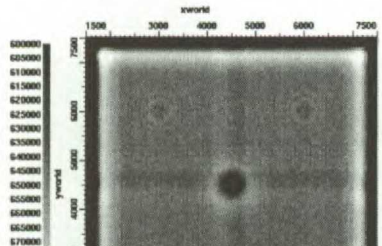


Fig. 4 Amplitude of horizontal event imaged by four adjacent cross-spreads. Note reduction of edge effects where two cross-spreads are adjacent.

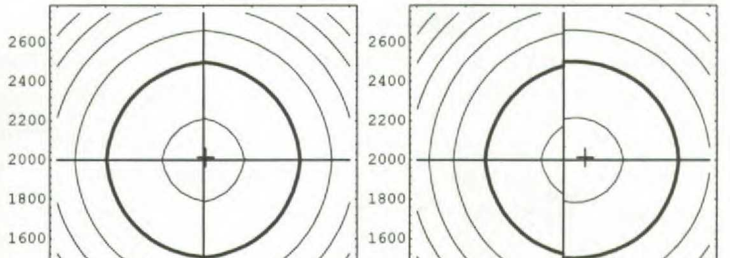


Fig. 5 Same as Fig. 2d, with four adjacent cross-spreads, for horizontal event with output point at four-corners point (left), and output point 100 m to the right of four-corners point (right). The discontinuities across the cross-spread edges explain the weak amplitudes in the centre of Fig. 4.