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Common-Refection-Surface (CRS) Stacking with Diffraction Moveouts of Varying Aperture

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SUMMARY

A modified version of the CRS stacking method based on diffraction moveouts with different midpoint and half-offset apertures is shown to provide clean stacked sections of reflection and diffraction events. Moreover, as the CRS diffraction moveout depends on fewer parameters than its counterpart conventional reflection moveout, the proposed approach also benefits from less computation effort. Illustrative real-data examples are provide showing good potential of the proposed approach.

Introduction

As already established in the literature, the Common-Reflection-Surface (CRS) stack method (Jäger, 2001) is based on the generalized hyperbolic moveout, which uses first and second derivatives with respect to midpoint and half-offset in the vicinity of a selected central or reference ray. In the general case of a finite-offset central ray, the number of parameters of the CRS moveout is five and fourteen for the 2D and 3D situations, respectively. In the simpler case, of much widespread use, where the central ray is a zero-offset (ZO) ray and also assuming non converted data and an isotropic medium, the number of CRS parameters significantly reduces to, respectively, three and eight parameters for 2D and 3D datasets. The 2D ZO CRS moveout has the expression

$$t^2(x_m, h) = [t_0 + A(x_m - x_0)]^2 + B(x_m - x_0)^2 + Ch^2 \,, \qquad (1)$$

where (x_m, h) denotes the midpoint and half-offset of a source receiver pair in the vicinity of the ZO central ray of coordinates, $(x_0, h_0 = 0)$, with coefficients (CRS parameters) given by

$$A = \frac{\partial t}{\partial x_m}, \qquad B = t_0 \frac{\partial^2 t}{\partial^2 x_m^2} \qquad \text{and} \qquad C = t_0 \frac{\partial^2 t}{\partial^2 h^2} \,, \qquad (2)$$

all derivatives being evaluated at $x_m = x_0$ and $h = 0$. It is well known that the parameter B, in equation (2), is by far the most unstable parameter, being attached to the so-called normal (N) wave and indirectly related to the curvature of the reflector at the normal-incident-point (NIP). This heavily contrasts with good behavior exhibited by the remaining parameters, A and C, respectively interpreted as slowness of the central ZO ray at its emergence point and the normal moveout (NMO) velocity. As the CRS-parameter B has the most unstable estimation, it would be attractive if, at least for initial estimations, one could use moveouts not dependent on that parameter.

CRS diffraction moveout

In the case of ZO CRS, if the reflector reduces to a point diffractor, the parameters B and C coincide, $(B = C)$. As a consequence, the moveout of equation (1) further simplifies to

$$t_D^2(x_m, h) = [t_0 + A(x_m - x_0)]^2 + C[(x_m - x_0)^2 + h^2] \,. \qquad (3)$$

and in order to avoid complications involved on its estimation, we propose in this work to use the diffraction moveout of equation (3), used with varying midpoint apertures, to replace the full CRS moveout given by equation (1). This amounts to bi-parametric (2D) and five-parametric (3D) simultaneous searches of A, (a scalar in 2D and a two-dimensional vector in 3D) and C (a scalar in 2D and a 2X2 symmetric matrix, three independent entries, in 3D). The proposed strategy is not new, but exists for more than a decade, having been presented by Garabito et al. (2001). The search for the third parameter, B (also a scalar in 2D or a 2X2 matrix in 3D) can be seen as a second step in the estimation procedure, which uses the previously estimations of A and C. Upgraded versions for 2D common-offset (CO) CRS can be found in Garabito et al (2013).

The physics behind the use of the CRS diffraction moveout (3) is quite simple: That moveout well approximates the actual reflection in apertures comparable to the Fresnel zone associated with the measurement configuration. This fact is very much corroborated by the good practical experience encountered in all Kirchhoff-type approximations, in particular in time and depth migration. We observe that the Fresnel zone is "small" for reflections and "large" for diffractions. As shown in Faccipieri et al. (2013) and Asgedom et al. (2013), the use of "large" (midpoint) apertures of the diffraction moveout can be very effective for imaging diffraction energy.

Real data example

The proposed approach is applied to a real dataset offshore Brazil with results shown in Figure 1. Reflection (conventional) CRS stack (top left) is compared with diffraction CRS stacks of varying midpoint apertures of 3 (top right), 55 (bottom left) and 105 (bottom right) traces. We see that for the least aperture, the diffraction CRS pretty much provides the same result as full CRS, namely with enhanced reflections and attenuated diffractions. As midpoint aperture increases, diffraction CRS enhances diffractions and attenuates reflections.

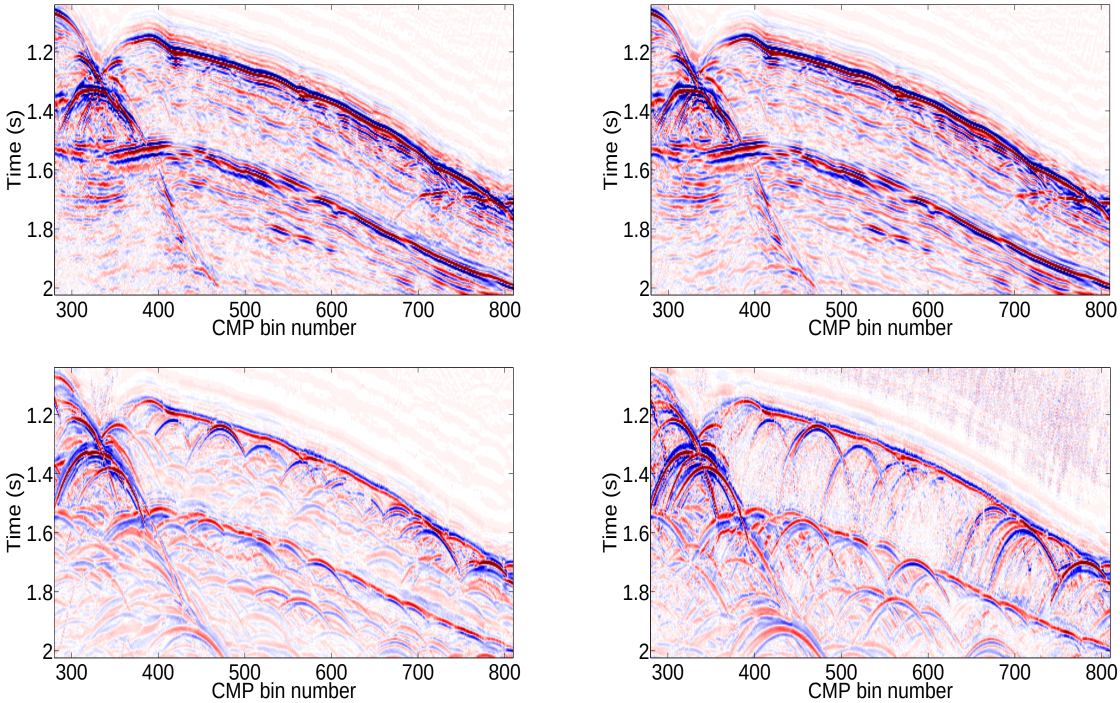

Figure 1 *Top left: CRS stacked section using the conventional reflection moveout with an aperture of 3 traces in midpoint direction. Top right: Global search over CRS diffraction moveout with an aperture of 3 traces. Bottom left and bottom right: 55 traces and 105 traces in midpoint direction, respectively. In all cases, 44 traces were used in the half-offset direction.*

Conclusions

CRS stacks obtained by the use of diffraction moveouts and "small" apertures in midpoint, produce comparable results as the ones of conventional CRS with full-parameter reflection moveouts. In both cases, reflections are enhanced and diffractions attenuated. However, the use of diffraction moveouts with "large" midpoint apertures, produce stacked sections in which diffractions are enhanced and reflections attenuated. The quantification of "small" and "large" apertures for optimal imaging of reflections and diffractions is a topic that deserves further investigation.

References

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