A comparison of standard migration with EOM for Hussar data

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Summary

Equivalent Offset Migration (EOM) is a method of prestack time migration based on the principles of Kirchhoff prestack time migration. It is simpler, faster, flexible and more reliable than the conventional methods.

The methods is divided in two steps: the first is the creation of common scatterpoint gathers(CSP) and the second is the application of a simplified Kirchhoff migration on the CSP, that consists of scaling, filtering, normal moveout (NMO) and stacking.

CSP gathers are created for each output migrated trace based on the EOM method. They have high fold and larger offset, which provide a better focus of the semblance plot and therefore improve the resolution of velocity analysis over conventional common midpoint gathers.

Introduction

Migration is one of the most important processes in seismic processing and it is used to move events to their correct positions in time and space.

This study provides a comparison between a standard poststack time migration and prestack time migration with EOM for a data set from Hussar, Alberta.

Kirchhoff Prestack Migration concepts

Kirchhoff prestack migration is based on a model of the subsurface as an organized set of scattered points. The model assumes that energy may come from a source located anywhere on the surface and is recorded by all receivers. The location of energy on a recorded trace is the total travel time along the ray path from the source down to the scatter point and back up to the receiver. Kirchhoff prestack migration assumes an output location, and then sums the appropriate energy from all available input traces.

From the raypaths shown in Figure 1, the traveltime *t* is estimated by the adding the time from the source to the scatter point t_s and time from the scatter point to the receiver t_r, or

$$t = t_s + t_r \qquad (1)$$

From the geometry, the total or two-way, travel time can be computed from:

$$t = \left[\left(\frac{t_0}{2}\right)^2 + \frac{(x+h)^2}{V_{mig}^2}\right]^{1/2} + \left[\left(\frac{t_0}{2}\right)^2 + \frac{(x-h)^2}{V_{mig}^2}\right]^{1/2}, \qquad (2)$$

The equation (2) is known as the double square root (DSR) equation and defines the traveltime surface over which the Kirchhoff summation or integration takes place.

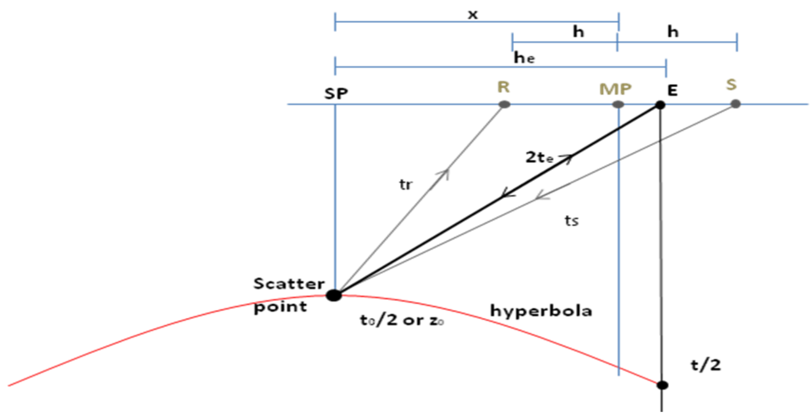

FIG. 1. Geometry of Kirchhoff prestack time migration with source S and receiver R. and equivalent offset h_e Taken and modified from Bancroft et al. 1998.

Equivalent Offset Migration

The equivalent offset is defined by converting the DSR equation (2) into an equivalent single square root or hyperbolic form (Bancroft et al., 1998). This can be reformulated by defining a new source and receiver collocated at the equivalent offset position E as illustrate in Figure 1. For convenience, the CSP gather is located at x = 0. The equivalent offset h_e is chosen to maintain the same traveltime from equation (1):

$$t = 2t_e = t_s + t_r \quad (3)$$

This traveltime can be written as:

$$2\left[\left(\frac{t_0}{2}\right)^2 + \frac{h_e^2}{V_{mig}^2}\right]^{1/2} = \left[\left(\frac{t_0}{2}\right)^2 + \frac{(x+h)^2}{V_{mig}^2}\right]^{1/2} + \left[\left(\frac{t_0}{2}\right)^2 + \frac{(x-h)^2}{V_{mig}^2}\right]^{1/2}. \quad (4)$$

This equation may be solved for the equivalent offset h_e to get:

$$h_e^2 = x^2 + h^2 - \left(\frac{2xh}{tV_{mig}}\right)^2. \quad (5)$$

The equivalent offset is a quadratic sum of the distance x between the CSP and the CMP, and h, the source-receiver half offset.

Examples

The data analysed in this study was acquired with 265 shots at 20 meters interval, and 224 receivers at 20 meters interval. The line length was 4480 meters. A vibroseis low-dwell sweep was used that moved slowly through the low frequencies at reduced power and then moved linearly through the frequency range of 1-100 Hz (Margrave, 2011).

The data set was prepared using a standard sequence processing: geometry, first breaks, statics, elevation statics, geometry spreading compensation, noise attenuation using Radial filter, Gabor deconvolution, velocity analysis, and stack. The first step of the EOM method was then applied: the creation of common scatterpoint (CSP) gathers. Figure 2 shows a two sided CDP gather (left) at the same location as a CSP gather (right). The CSP gather contains much higher fold and shows more coherence energy than does the CMP gather.

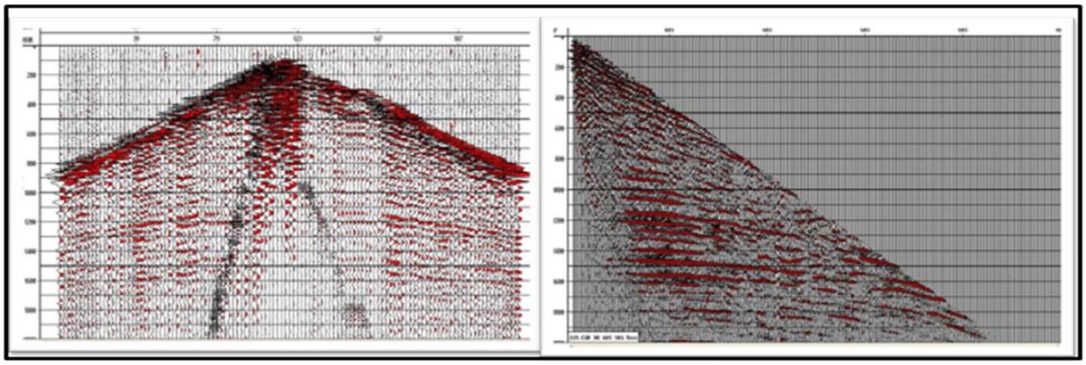

FIG. 2. Two-side CMP gather to the left and one side CSP gather to the right at the same location. Taken from Guirigay et al. 2011.

After the CSPs are formed, the second step in the EOM method consists of scaling, filtering, normal moveout (NMO) and stacking to complete the prestack migration.

Figure 3 shows semblance plots for a CDP (left) and the semblance analysis for CSP gathers at the same CMP location. The CSP semblance shows improved velocity resolution because of the higher fold and larger offsets than in the CMPs.

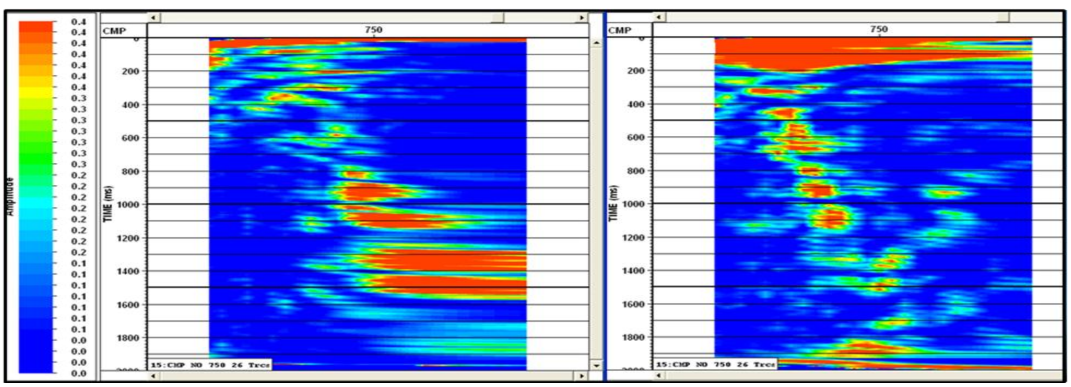

FIG. 3. Semblance display for a CMP (left) and a CSP gather (right) at the same location

Figure 4 shows a comparison between a migrated section using Poststack Kirchhoff Migration and an EOM stacked section. Many of the main reflectors can be seen in both sections. However, the section with poststack migration shows discontinuous reflectors below 1400 milliseconds that are not observed in the EOM section.

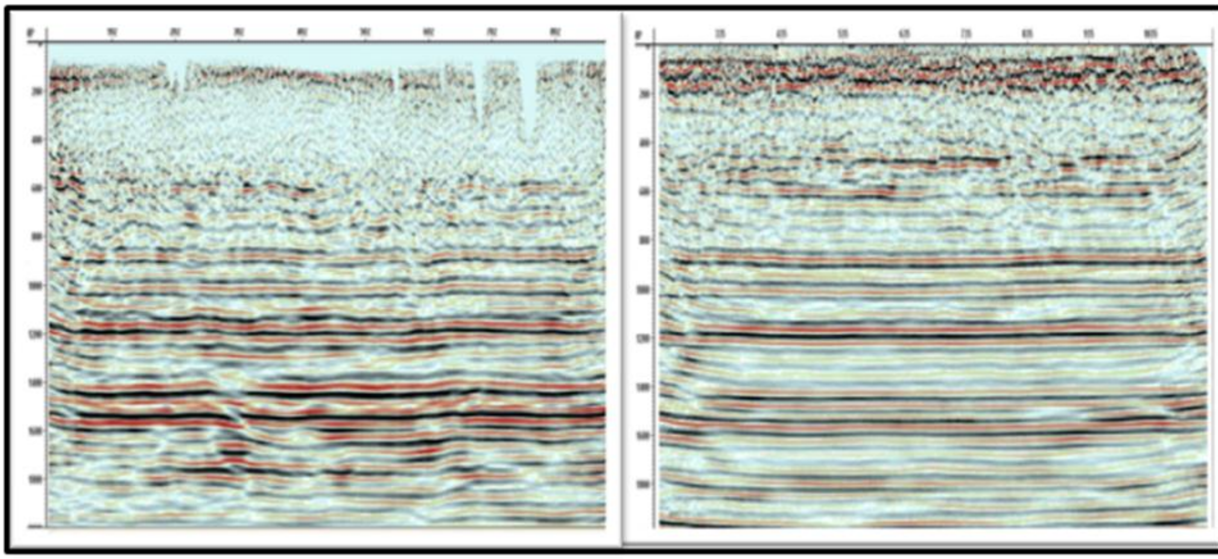

FIG. 4. Kirchhoff poststack migration (left) and EOM stacked section using a V(t) (right)

Conclusions

EOM is a method of prestack migration based on the principle of Kirchhoff time migration. This method is simpler, faster, flexible, and more reliable than conventional methods.

EOM uses an equivalent offset to form CSP gathers. Standard processing of the CSP gathers with NMO and stacking completes the prestack migration process.

The CSP gathers have high fold and longer offsets than CMP gathers at the same location, which allows an improvement of the velocity resolution.

Comparison between EOM and PSTM Kirchhoff sections shows that the EOM data have improved coherence and interpretability.

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