Histograms of the Kirchhoff migration operator

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ABSTRACT

A method of Kirchhoff migration is examined which utilizes a histogram to isolate coherent energy along each diffraction. The method explored is data driven as opposed to model driven, which allows the definition of a space varying migration aperture without the need for a preconceived model.

In this method, a histogram is formed form the frequency of occurrence of amplitudes along each diffraction shape that is defined by Kirchhoff migration. It was found that if a constant amplitude scale is applied to our histogram, similar results are produced by applying an energy threshold mute to the data. It was also found that varying the histogram amplitude scale, according to the maximum energy on each diffraction shape, biased small amplitude data which contributed noise to the aliased the migration output.

It was concluded that this method works well for eliminating noise and spikes in the data while preserving dipping and flat events, along with diffraction events.

INTRODUCTION

Aliased noise can come from the input data and/or from the migration operator. The migration operator should contain an antialiasing filter to prevent aliasing of unaliased energy, however it does not remove energy from an aliased reflection. The objective of this process is to identify the aliased energy and remove it, while retaining the reflection energy.

A numerical input model, called Mod50 (Figure 1), was used to perform our migration and test our method. This model contains linear and dipping reflections, diffractions, and localized points of reflection energy. It has 150 traces with a trace interval of 100 ft, 750 time samples at 2 ms, and a velocity of 10,000 ft/s.

The left of Figure 1 is the time section to be migrated, with the amplitude of the FK transform on the right. The steepest dip (encircled in blue) is aliased as evident in the FK transform where energy departs on the right and re-enters on the left, (encircled in red).

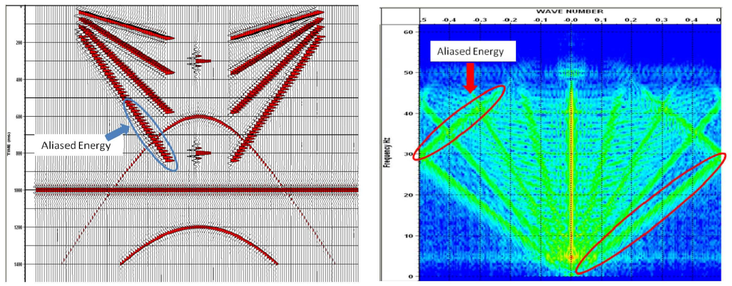

FIG. 1 The input time section in a), and the FK transform in b), illustrating aliasing of the steeply dipping event.

COHERENT AND ALIASED ENERGY

Figure 2a shows a diffraction shape (illustrated, not the true diffraction) which is tangential at location A and also passes through events at B and C that are not tangential. The diffraction shape in (b) passes through events A to G, but is not tangential to any of these events.

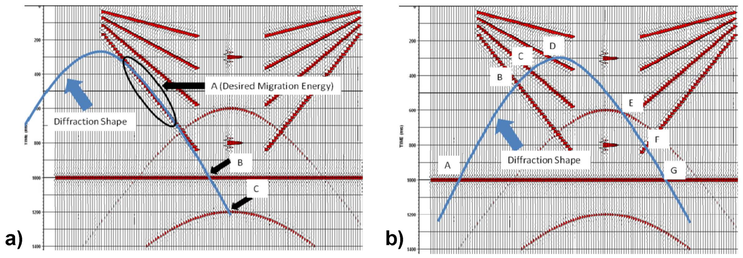

FIG. 2 Diffractions in a) is tangential to a reflection at A but not in b).

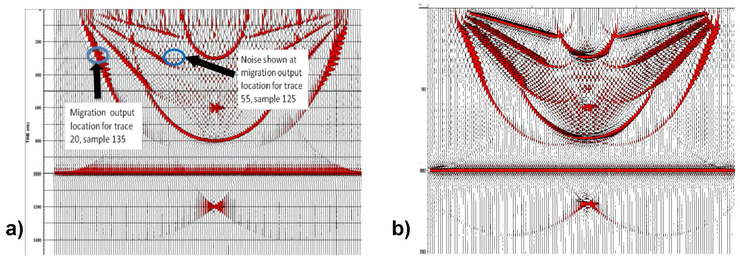

FIG. 3 Migrations showing in a) a Kirchhoff migration with no AAF and b) an FK migration illustrating the aliased energy from the dipping event.

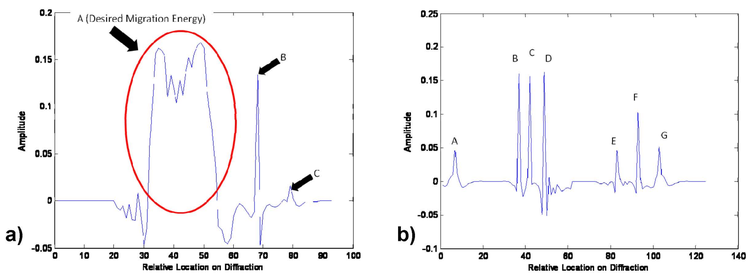

FIG. 4 Amplitudes along the corresponding diffractions in Figure 2. The coherent reflection energy in a) is encircled in red, other events are aliased.

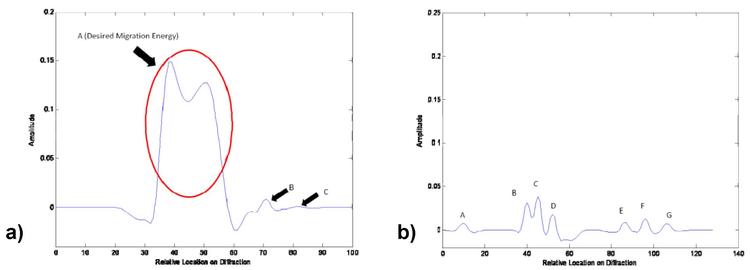

FIG. 5 Smoothing of the events in Figure 4 to discriminate the reflected energy from the aliased energy. A convolution type filter was used.

HISTOGRAMS

The amplitudes in Figure 5a were used to create the histogram displayed in Figure 6a. There are a lot of low amplitudes in the diffraction array that become clustered as high amplitudes in the in the central portion of the histogram. In contrast, the amplitudes of the tangential energy have a lower amplitude that is clustered away from the center.

The aliased energy can be zeroed to leave the tangential energy as illustrated in Figure 6b. This tangential energy is then summed and placed into the migration point that defined the diffraction. Figures 7 and 8 demonstrate two migrations with different threshold values.

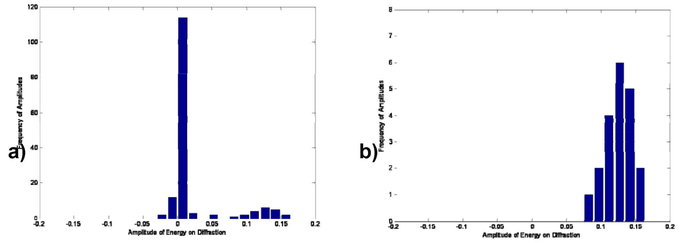

FIG. 6 Histogram of a) the diffraction amplitude in Figure 5a, and b) with the central area removed.

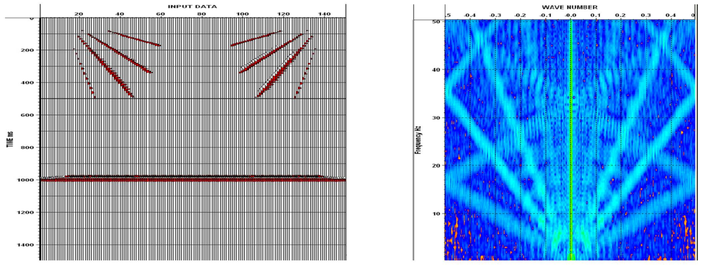

FIG. 7 The migration and the FK, histogram threshold of 0.l,.

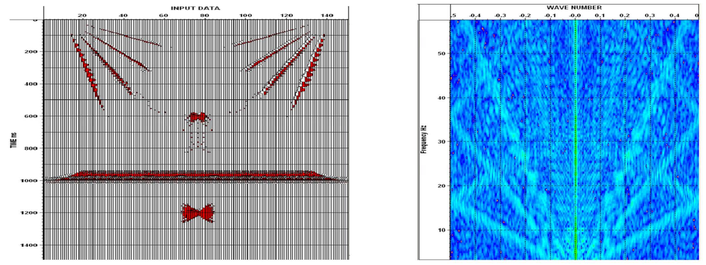

FIG. 8 Migration and FK, histogram threshold of 0.05.

CONCLUSIONS

A feasibility study was presented for a migration algorithm to remove aliased energy using a histogram of the amplitudes along a diffraction.

The method is data driven and is not based on any preconceived model of the subsurface.

The method demonstrates that an aliased, steeply dipping event, can be migrated without creating the traditional noise from aliasing.