

F-K MIGRATION USING EAVESDROPPER SEISMIC PROCESSING PACKAGE

by

Richard D. Miller

of the

Kansas Geological Survey

The University of Kansas

Lawrence, Kansas 66046

Kansas Geological Survey

Open-file Report No. 92-3

February 1992

Migration is a correction for optical distortion that results from dipping beds, bed termination, and velocity variation. Migration is defined by Sheriff, 1991 as:

An inversion operation involving rearrangement of seismic information elements so that reflections and diffractions are plotted at their true locations. The need for this arises since variable velocities and dipping horizons cause these elements to be recorded at surface positions different from the subsurface positions.

Data can be migrated by integration along diffraction curves (Kirchoff migration), numerical finite-difference, or equivalent operations in frequency-wavenumber domain (f-k migration). The Stolt method (Stolt, 1978) of f-k migration is the method employed by Eavesdropper software.

The Stolt method of migration is exact for a constant-velocity medium (Yilmaz, 1988). Rarely is a constant velocity model valid for a stacked section (zero-offset). The Stolt method of migration involves conversion of a zero-offset NMO corrected time section (t,x) into the frequency-wavenumber (f-k) domain where a geometric rotation accounting for dip is performed, followed by a reverse transformation. The conversion process involves a Fast Fourier Transform (FFT), which is an operation that transforms information represented in the time/distance space to equivalent information in frequency space. Once in the frequency domain the process of migration basically involves the rotation of radial lines (coherent events in the time domain) in the 2-D amplitude spectrum (frequency domain) outwards and away from the zero wavenumber axis (Figure 1). This rotation is analogous to opening a fan. The steepest events in the time domain will be represented

as the steepest and most distant parts of the fan. The steeper the dip of the reflection in the time domain the closer to the radial line is to the wavenumber axis in the frequency domain. After migration is complete in the f-k domain the section is converted back to the x,t domain. After migration the steepness of events are reduced in the frequency domain but after transformation back to the time domain will experience an increase in apparent dip.

The amount of rotation necessary to properly correct for dip in the f-k domain is dependent on time (depth) and velocity of the equivalent reflecting event in the x,t domain. The f-k method handles diffractions as a series of discrete dipping events. Therefore, correction for both dipping beds and diffraction events can be accomplished with a single pass. The effectiveness of f-k migration is dependent how closely the time section to be migrated simulates a constant velocity section. Eavesdropper uses the constant velocity algorithm (Stolt, 1973) which assumes the velocity function can be reasonably well defined by a single velocity. The generalized Stolt migration algorithm uses a stretching operation to approximate constant velocity sections from time varying velocity sections. The closer the time section simulates a constant velocity section the more exact the resulting correction.

The effectiveness of migration is not generally evident on shallow seismic reflection data (target depths of between 2 and 50 m) acquired for engineering, ground water, environmental, or mining studies. At shallow depths seismic velocities can vary by over an order of magnitude with potential to be less than the speed of sound in air. If velocities are low enough, the migration operator will shift the position of points by less than a single trace or time sample and data could appear undermigrated. In such cases migration cannot have any positive effect on the seismic image, and is

unnecessary at best. Calculations based on the "migrator's equation" (Stolt, 1978; Robinson, 1982; Chun and Jacewitz, 1981; Uren, et al., 1990) can be used to predict whether migration of an arbitrary shallow seismic stack is advisable.

**OPERATION OF MIGOS ALGORITHM CONTAINED WITHIN
EAVESDROPPER SEISMIC PROCESSING PACKAGE**

Required input files and parameters include:

INPUT FILENAME

OUTPUT FILENAME

STARTING CDP

ENDING CDP

CDP TRACE SPACING (usually equal to 1/2 original station spacing)

ONE WAY VELOCITY (1/2 of stacking velocity)

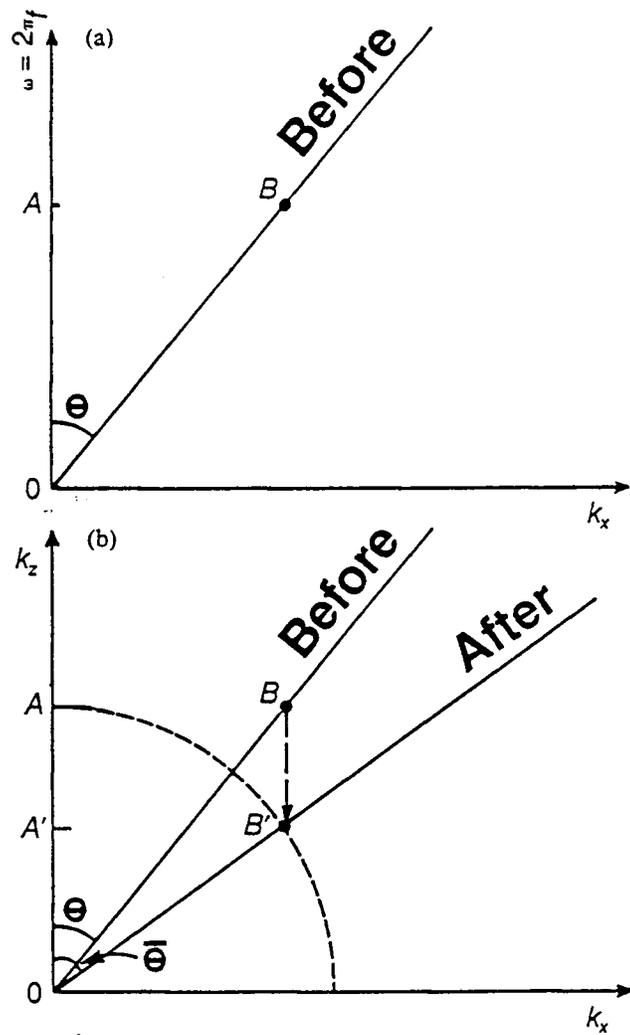
ALL (transform from x,t space to f-k space, rotate, and transform back from f-k space to x,t space)

2D-FFT (only perform 2-D transformation from x,t domain to f-k domain)

INTERPOLATION AND 2D-IFFT (perform the rotation and the transform back from f-k space to x,t space)

REFERENCES

- Chun, J.H., and Jacewitz, C., 1981, Fundamentals of frequency-domain migration, *Geophysics*, 46, 717-732.
- Robinson, E.A., 1982, Migration of geophysical data: D. Reidel Publ. Co.
- Sheriff, R.E., 1991, Encyclopedic dictionary of exploration geophysics: Soc. of Expl. Geophys.
- Stolt, R.H., 1978, Migration by Fourier transform, *Geophysics*, 43, 23-48.
- Uren, N.F., Gardner, G.H.F., and McDonald, J.A., 1990, The migrator's equation for anisotropic media, *Geophysics*, 55, 1429-1434.
- Yilmaz, O., 1988, Seismic data processing, investigations in *Geophysics* No. 2, Soc. Expl. Geophys.



1
 FIG. Migration in the (f, k) domain. (a) A dipping reflector is represented by a radial line OB in the (f, k) plane. (b) After migration, the radial line OB maps onto another radial line OB' , while B maps onto B' . The horizontal wavenumber is invariant under migration. For comparison, the f - k response of the dipping event before migration (a) has been superimposed on that after migration (b). (Adapted from Chun and Jacewitz, 1981.)