EAGE

SS18

Azimuth and Angle Gathers from Wave Equation Imaging in VTI Media

T. Alkhalifah* (KAUST) & S. Fomel (University of Texas, Austin)

SUMMARY

Angles in common-image angle domain gathers refer to the scattering angle at the reflector and provide a natural access to analyzing migration velocities and amplitudes. In the case of anisotropic media, the importance of angle gathers is enhanced by the need to properly estimate multiple anisotropic parameters for a proper representation of the medium. We extract angle gathers for each downward-continuation step from converting offset-space-frequency planes into angle-space planes simultaneously with applying the imaging condition in a transversely isotropic (VTI) medium. The analytic equations, though cumbersome, are exact within the framework of the acoustic approximation. They are also easily programmable and show that angle gather mapping in the case anisotropic media differs from its isotropic counterpart, difference depending mainly on the strength of anisotropy.

Azimuth and Angle gathers from wave equation imaging in VTI media

Tariq Alkhalifah, KAUST, and Sergey Fomel, The University of Texas at Austin

Downward wave extrapolation provides an accurate method of seismic imaging in structurally complex areas. Downward wave extrapolation is also naturally formulated to produce azimuth and angle gathers, which have some attractive features over common-offset gathers, chief among which is a better representation in the case of multipathing in complex media. Fomel (2004) showed that structural dependence can be removed in a depth-slice approach to extracting angle gathers. Specifically, one can generate gathers at each depth level, converting offset-space-frequency planes into angle-space planes and applying simultaneously the imaging condition. The improved mapping retains velocity dependence but removes the effect of the structure. Because of its ray-parameter-based (Fourier) formulation, this approach lends itself naturally to an anisotropic phase-velocity extension.

Migration velocity analysis in anisotropic media remains a challenging and open issue. Multiple parameters are needed to represent the anisotropic model. For a transversely isotropic medium with vertical axis of symmetry (VTI media), only NMO velocity (v) and the non-elliptic parameter (η) predominantly influence imaging (Alkhalifah and Tsvankin, 1995). Vertical velocity (v_z) controls mainly placement of the image in depth. Nevertheless, estimating even two parameters that can vary laterally and vertically from image gathers is difficult. Angle gathers provide an opportunity to use residual moveout and amplitude information to help update anisotropic parameters. Biondi (2007) suggested an approach to extracting angle gathers in anisotropic media from post-migration data. His formulation relies on ray information that is hard to examine analytically.

Angles in common-image angle-domain gathers refer to the scattering angle at the reflector and provide a natural access to analyzing migration velocities and amplitudes. In the case of anisotropic media, we extract angle gathers for each downward-continuation step from converting offset-space-frequency planes into angle-space planes simultaneously with applying the imaging condition in a transversely isotropic (VTI) medium. The analytic equations, though cumbersome, are exact within the framework of the acoustic approximation. They are also easily programmable and show that angle gather mapping in the case anisotropic media differs from its isotropic counterpart, difference depending mainly on the strength of anisotropy. Since VTI media are azimuth independent, the formulas are directly applicable to multi azimuth by including addiional axes for offset and midpoint. Application examples will be included in the presentation.

NUMERICAL EXAMPLES

We evaluate angle gathers for a single azimuth as a function of offset and midpoint wavenumbers for a given frequency. Figures 1 and 2 show a contour density plot of angle gathers as a function of offset and midpoint wavenumbers, for a 60-Hz frequency slice and a single depth step during downward continuation. In Figure 1 the medium is isotropic, with a velocity of 2000 m/s. Clearly, for $k_{hx} = 0$, the angle gather is zero regardless of the midpoint wavenumber, which is expected, because for zero-offset the scattering or opening angle is equal to zero. Also, we realize that angles decrease with dip for a given offset wavenumber, which is also expected, because for any offset a scattering angle becomes zero for a vertical reflector.

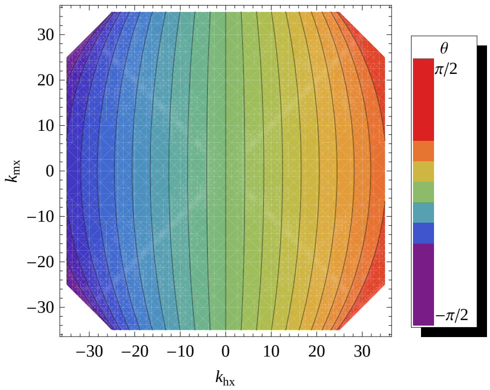

Figure 1: Constant-depth constant-frequency (60 Hz) slice mapped to reflection angles for an isotropic medium with velocity equal to 2000 m/s. Zero-offset wavenumber maps to zero (normal incidence) angle. The four blank corners represent evanescent regions.

For anisotropic media, Figure 2 for η equal to 0.3, the angles decrease with dip for a constant offset wavenumber faster than in the isotropic case. Considering that v_z is lower in the anisotropic models, the higher horizontal velocities given by the larger η resulted in smaller scattering angles because reflection occurs more toward the updip side for larger η.

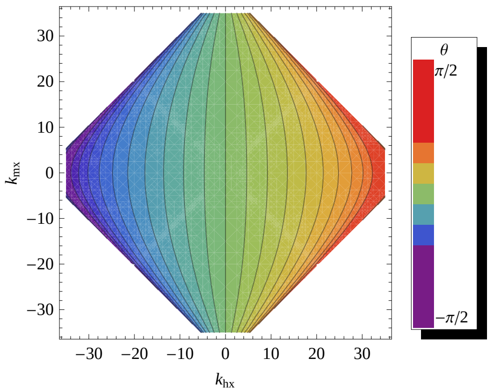

Figure 2: Constant-depth constant-frequency (60 Hz) slice mapped to reflection angles as in Figure 1, but for a VTI model with v_z=1800 m/s, v=2000 m/s, and $\eta = 0.3$.

REFERENCES

Alkhalifah, T., and I. Tsvankin, 1995, Velocity analysis for transversely isotropic media: Geophysics, **60**, 1550–1566.

Biondi, B., 2007, Angle-domain common-image gathers from anisotropic migration: Geophysics, **72**, 581–591.

Fomel, S., 2004, Theory of 3D angle gathers in wave-equation imaging: 74th Ann. Internat. Mtg., Soc. of Expl. Geophys., 1053–1056.