LONG-OFFSET MOVEOUT APPROXIMATION IN LAYERED ELASTIC ORTHORHOMBIC MEDIA

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Considering vertically varying layered elastic orthorhombic media, we derive a “complete” set of effective parameters that allows accurate approximation of azimuthally dependent traveltime (moveout) for short, moderate and long offsets.

The short/moderate offset parameters are described in terms of eight effective parameters, where three are hyperbolic (the fast and slow normal moveout velocities and the azimuth of the slow velocity), and the other five describe the fourth-order azimuthally dependent effective velocity (or alternatively, the azimuthally dependent effective anellipticity eta). The fourth-order velocity is presented as a bilinear form of two vectors and a matrix. The matrix components depend only on the three hyperbolic coefficients, where one of the vectors depends on the five fourth-order coefficients, and the other depends on the phase velocity azimuth alone. For a fixed azimuth, the short/moderate offset traveltime approximation includes only two coefficients (in addition to the zero-offset time).

For the long offsets, we approximate the moveout for nearly horizontal rays in the proximity of the critical slowness. For this, we distinguish between the “fast” layer (with the fastest horizontal velocity for the given azimuth), and the other, “slow” layers. In the series expansion of the two offset/traveltime components for nearly critical slowness, we keep two coefficients per azimuth as well. One of these is responsible for the infinite (unbounded) parts of the offset and traveltime related to nearly horizontal propagation and depends on the properties of the fast layer. The other one depends on the contributions of the “slow” layers to the offset and traveltime. To obtain these contributions, we assume that in the fast layer the propagation is nearly horizontal, and we apply Snell’s law to establish the vertical slowness in each of the other layers.

Our derivation starts with analyzing single-layer (local) parameters. By splitting the offset into two components - lengthwise and transverse, along and perpendicular to the phase velocity azimuth, respectively - we are then able to integrate the local parameters to obtain global effective parameters. A generalized Dix-type inversion can also be applied to obtain local (layer) parameters from global top and bottom horizon parameters.

Finally, for any azimuth, we “glue” the moveout coefficients for small/moderate and nearly critical slowness (short and long offsets) into a unique function valid for the whole feasible range of the horizontal slowness magnitude.

We perform a number of numerical tests to evaluate the attainable accuracy, comparing the suggested approximation with numerical ray tracing. The results along both two ends of the slowness interval are extremely accurate, where obviously some small errors still remain at intermediate offsets. The technique may be used for both modeling and inversion; in particular, to approximate full-azimuth residual moveouts obtained by anisotropic migrations, and to further update the elastic parameters of the background orthorhombic models used in the migration.