SECOND DERIVATIVES OF TRAVEL TIME FOR TIME MIGRATION WITHOUT VELOCITY MODEL

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It is possible to find the velocity and the reflector below an effectively constant velocity layer by using travel times and horizontal slownesses, also called local event slopes, of the reflected rays. According to Sword (1987), the idea of using horizontal slownesses to obtain migration velocity as well as the location goes back to Puzyrev, Riznichenko and Rudnev in 1940s. Goldin (1986) was probably the first to publish the approach in English literature. Sword (1987) presents this constant effective velocity prestack time migration alongside his tomography approach. Migration proposed by Fomel (2007) is equivalent to these migrations. The idea of using horizontal slowness was also used by Kleyn (1977) for zero-offset migration, and by Ottolini (1983) for migration of horizontal reflectors. Cooke et al. (2009) present another point of view on this time migration without velocity model, where we use the resulting migration velocity to perform multiples suppression. All of these formulations require the horizontal slownesses in two domains: some in common-offset and common-midpoint – e.g. Fomel (2007) – and some in common-shot and common-receiver domains – e.g. Cooke et al. (2009). However, the information about the slowness is not always available in two domains: for example the spacing between sources can be too large or there are only few sources available.

To address this issue, I formulate a new method for prestack time migration without velocity model that requires data only in one domain; it uses the first and the second derivatives of the travel time with respect to the location of the receiver in a common-shot gather. As with the other methods, I assume that the signal propagates through a constant effective velocity layer. Moreover, I assume that the reflector is locally planar, with an arbitrary dip. First, I describe the theory of the migration algorithm. Second, I illustrate the applications and limitations of the method on synthetic examples. I also present the method in 3D, where it requires the second derivative only in one direction, which makes the method suitable for marine seismic where one can twice differentiate along the streamer direction.

References

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