Joint Migration Inversion: simultaneous imaging and velocity estimation including all scattering effects

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SUMMARY
We propose a joint migration inversion algorithm that aims at combining the best elements of imaging, migration velocity analysis and full waveform inversion. It uses seismic reflection data in a hands-off, closed-loop process by matching forward modeled responses to measured field data in a full waveform way. The modeling process is based on an operator description of the subsurface and includes all multiples (surface and internal) and transmission effects (down and up). The output contains both the migration velocity model and the migrated image.

INTRODUCTION
To handle more complex subsurface structures in velocity estimation, a trend can be observed toward full waveform schemes that fully take into account complex propagation effects (Virieux and Operto, 2009). Full waveform inversion (Tarantola, 1984) attempts to exactly fit full waveform modeled data with measured data. As discussed by Symes (2008) and Virieux and Operto (2009), this approach has many local minima, which can be relaxed if FWI is applied to the low frequency components of diving waves only (Operto et al., 2004; Plessix et al., 2010).

Wave equation migration velocity analysis (WEMVA) (Sava and Biondi, 2004) attempts to optimize application of the imaging condition in migration iteratively. The method is very suitable for finding a smooth macro-velocity model (Symes, 2008) and it can handle much more complexity in the subsurface compared to time-picking algorithms. Downside is that internal multiples cannot be correctly handled. Recently we have seen attempts to combine WEMVA and FWI into a single inversion scheme by Fleury and Perrone (2012), Biondi and Almomin (2012) and Zhou et al. (2012).

All these approaches focus on imaging and velocity updating by using primary reflections.

This presentation presents Joint Migration Inversion (JMI), a full wavefield/waveform migration-inversion scheme for seismic reflection data that combines migration with tomographic inversion. It includes all multiple reflection events without explicitly defining reflecting boundaries in the velocity model.

JOINT MIGRATION INVERSION (JMI)

The feedback engine of the closed-loop JMI method is the operator-driven forward modelling module, being referred to as Full Wavefield Modeling (FWMod). FWMod is described in Berkhout (2012), Davydenko and Verschuur (2012) and Berkhout (2014a). With this recursive and iterative two-way modelling process, the seismic reflection responses are generated from the estimated propagation and reflectivity operators. All multiples and transmission effects are included.

Next, the modeled responses are compared to the measured ones and the resulting residual data is back-projected into the subsurface via reverse wavefield extrapolation. At each depth level the residual data is transformed into updates of reflectivity, being amplitude-driven, and velocity, being phase-driven (Berkhout, 2012; Staal and Verschuur, 2012; Berkhout 2014b,c). The iterative process stops when all the residual shot records are below a pre-specified threshold.

In the past years we have developed a fully automatic nonlinear migration-inversion package (JMI). JMI images provide true-amplitude reflectivity information and resolve primary shadow zones as well as interference from overburden multiples. We expect that JMI is very suited to solve the imaging problems of deep reservoirs below very complex overburdens.

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REFERENCES


