

ELASTIC WAVE MODE DECOUPLING FOR SEISMIC IMAGING AND INVERSION

Jiubing Cheng, Chenlong Wang and Tengfei Wang, Tongji University

Recent hardware advances have made the acquisition of multicomponent data much more widespread. This technique aims to record and utilize both compressional (P) and shear (S) wave modes to capture more information related to rock properties and thus allow more accurate estimation of key reservoir characteristics. As the industry turns towards higher-risk conventional reservoirs and unconventional sources of hydrocarbons, multicomponent seismic will play more significant role than before. However, in addition to very difficult statics and velocity analysis problems, today's imaging approaches are still not good enough for multicomponent seismic data.

Generally, the elastic seismic data are separated into single mode and then processed by extensions of techniques used for scalar and acoustic wave fields. This may lose significant information that indicates lithology and fluid properties due to ignoring some elastic effects and unsuccessful P/S separation on the acquisition surface. Elastic Kirchhoff migration and elastic reverse-time migration (ERTM) algorithms have shown some promise. However, it was difficult to obtain physically interpretable images because of the cross-talks of wave modes propagating in an elastic media. To tackle this problem, many people have developed elastic imaging methods helped by mode separation based on Helmholtz decomposition. But mode separation using divergence- and curl-like operators is not mutually consistent for producing 3D converted wave images. We propose a new imaging condition based on high-fidelity vector decomposition of the elastic wavefields (Zhang & McMechan, 2010). This approach automatically avoids polarity reversal on the PS or SP migration images and can be easily extended to angle-domain ERTM using polarization directions of the vector P- and S-wave fields for heterogeneous isotropic and transversely isotropic (TI) media.

Over the past years, the industry as a whole has been making large strides toward using full-waveform inversion (FWI) using traveltime, amplitude and phase information to build more accurate velocity models for prestack depth migrations. Elastic full-waveform inversion (EFWI), in the manner of Tarantola (1986), offers the ability to invert multicomponent seismic data for elastic parameters of the subsurface. It has been applied to real data from North Sea and the Gulf of Mexico. Different from FWI of single measurement (pressure/vertical component) data, EFWI will introduce more parameters. The trade-off between parameters will increase the ill-posedness of the inverse problem. Various multistage strategies are proposed to successively operate on different parameter classes, or different subsets of seismic data or using different data-fitting to obtain more reliable inverted models. Through the observation of the radiation patterns with perturbation of elastic parameters, we propose an EFWI approach utilizing wave mode decoupling to mitigate multi-parameter trade-off in transmission and reflection experiments.

Preliminary results will be shown to demonstrate the benefits of mode decoupling for ERTM and EFWI.

References

- Tarantola, A., 1986, A strategy for nonlinear elastic inversion of seismic reflection data: *Geophysics*, 51, 1893–1903.
- Zhang, Q., and G. A. McMechan, 2010, 2D and 3D elastic wavefield vector decomposition in the wavenumber domain for VTI media: *Geophysics*, 75, D13–D26.