



Society of Exploration Geophysicists
The international society of applied geophysics

2015 North America Honorary Lecturer

Concepts and applications of imaging with multiples and primaries

*Presented by Dan Whitmore
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The goal of seismic acquisition and processing is to create a well-sampled image of the subsurface. Broadband acquisition has expanded the useable low and high frequencies of the seismic signal. Multistreamer acquisition provides a much greater receiver sampling. Wide- and full-azimuth acquisition and longer offsets have improved the azimuthal and angular illumination. The increased receiver coverage allows for a more complete sampling of the total wavefield. Multicomponent sensor technology both provides broadband acquisition and allows for separation of the downgoing and upgoing wavefields at the receivers, which subsequently can be used in imaging. Alternatively, there has been an increase in the use of ocean-bottom seismic, where the receiver sampling is relatively sparse, but the source sampling is typically dense. This presentation discusses imaging methods that take advantage of these advances in acquisition.

There is an array of imaging methods to choose from, including (1) fast beam methods used in model building, (2) Kirchhoff methods to address high-resolution imaging, (3) wavefield depth extrapolation and migration (WEM) used in more complex media, and (4) reverse time migration (RTM) for complex media and arbitrary dip.

This talk gives an overview of the principles and applications of RTM and WEM, which employ wavefield propagation of incident and reflected wavefields as part of their imaging process. It focuses on the combined use of single and higher order scattered wavefields, where the downgoing and upgoing wavefields can be used to construct subsurface images using both multiples and primaries.

The presentation covers the following topics:

- (1) Prerequisites of processing before imaging, including designature, deghosting, wavefield separation, and possibly surface-related multiple estimation
- (2) WEM and RTM imaging methods, including discussions on wavefield extrapolation, imaging conditions, and subsurface angle decompositions
- (3) Imaging of primary and secondary (multiple) reflections using upgoing and downgoing separated wavefields. Also included is the estimation of surface-related multiple noise and subtraction in the image space.
- (4) Beyond first-order imaging, including a discussion of trends in using inversion to achieve full-wavefield imaging

A number of examples will be shown, including:

- (1) Imaging of primaries and multiples in deepwater and wide azimuth scenarios
- (2) High-resolution imaging of primaries and multiples in shallow-water scenarios
- (3) Imaging of ocean-bottom seismic, comparing the imaged upgoing primaries, mirror images, and full wavefield images using multiples

Biography

Dan Whitmore received a Ph.D. in geophysics in 1995 at the University of Tulsa for his research into the methods for plane wave imaging. He has 40 years of experience in geophysical research and applications in the areas of seismic modeling, processing, velocity estimation, multicomponent imaging and 3D imaging. He served as an individual contributor, mentor, instructor, consultant, and leader in seismic imaging technologies at Amoco, ConocoPhillips, and currently for Petroleum Geo-Services.

He joined Amoco Research in 1974 and began working in the pioneering group that developed finite difference wavefield modeling. He developed one of the earliest implementations of reverse time migration (RTM) in 1979 and demonstrated the ability of RTM to image arbitrary subsurface complexity and image data beyond 90 dip. In 2011 he received the Society of Exploration Geophysicists Reginald Fessenden Award for the development of RTM.

Upon joining ConocoPhillips in 2001, Dan achieved the rank of geoscience fellow. He was an advisor in 3D imaging, 3D plane wave migration, and 3D tomographic velocity estimation. He served as the team leader of the Elastic Wave Technology project with specific emphasis on joint PP-PS imaging of North Sea reservoirs and providing technical input to the planning for a Life of Fields permanent monitoring system at Ekofisk Field.

He joined Petroleum Geo-Services in 2009 and is presently a geophysical advisor in the depth imaging department, providing technical guidance and depth-imaging support in the application of 3D RTM to wide- and full-azimuth data.



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