

## **Full Waveform Inversion hits the mainstream**

*With widespread adoption, the industry is reaping the benefits of high-resolution velocity models and clearer subsurface imaging.*

By CGG

Over recent years, Full Waveform Inversion (FWI) has become a widely adopted seismic technique. It has evolved from a specialist tool to one with applications in many different scenarios and environments. CGG has been at the forefront of this evolution, developing FWI from an academic research application into a mainstream production product. FWI is now an important component of the velocity model building toolset.

FWI uses every aspect of the recorded seismic, including parts which are often removed during conventional seismic processing, so the input data is generally kept as raw as possible. The technique updates the velocity model by minimizing the mismatch between the observed seismic data and data modelled through the current earth model. FWI velocity models are of much higher resolution than those generated by conventional methods and, in fact, the FWI velocity models can be as spatially well resolved as the seismic images themselves.

FWI provides a step-change in the modeling of complex velocity structure, which can be associated with the presence of a wide range of geological phenomena such as shallow gas, paleo-channels, supra-salt sediment carapace or permafrost zones. In such cases, the highly-variable shallow geology causes shadow zones and distortions in the seismic image. These inevitably hinder our ability to accurately image the deeper earth. The accurate and detailed models produced by FWI can be used by imaging algorithms, such as Reverse Time Migration (RTM), to provide clearer subsurface images, thus facilitating better interpretation and understanding.

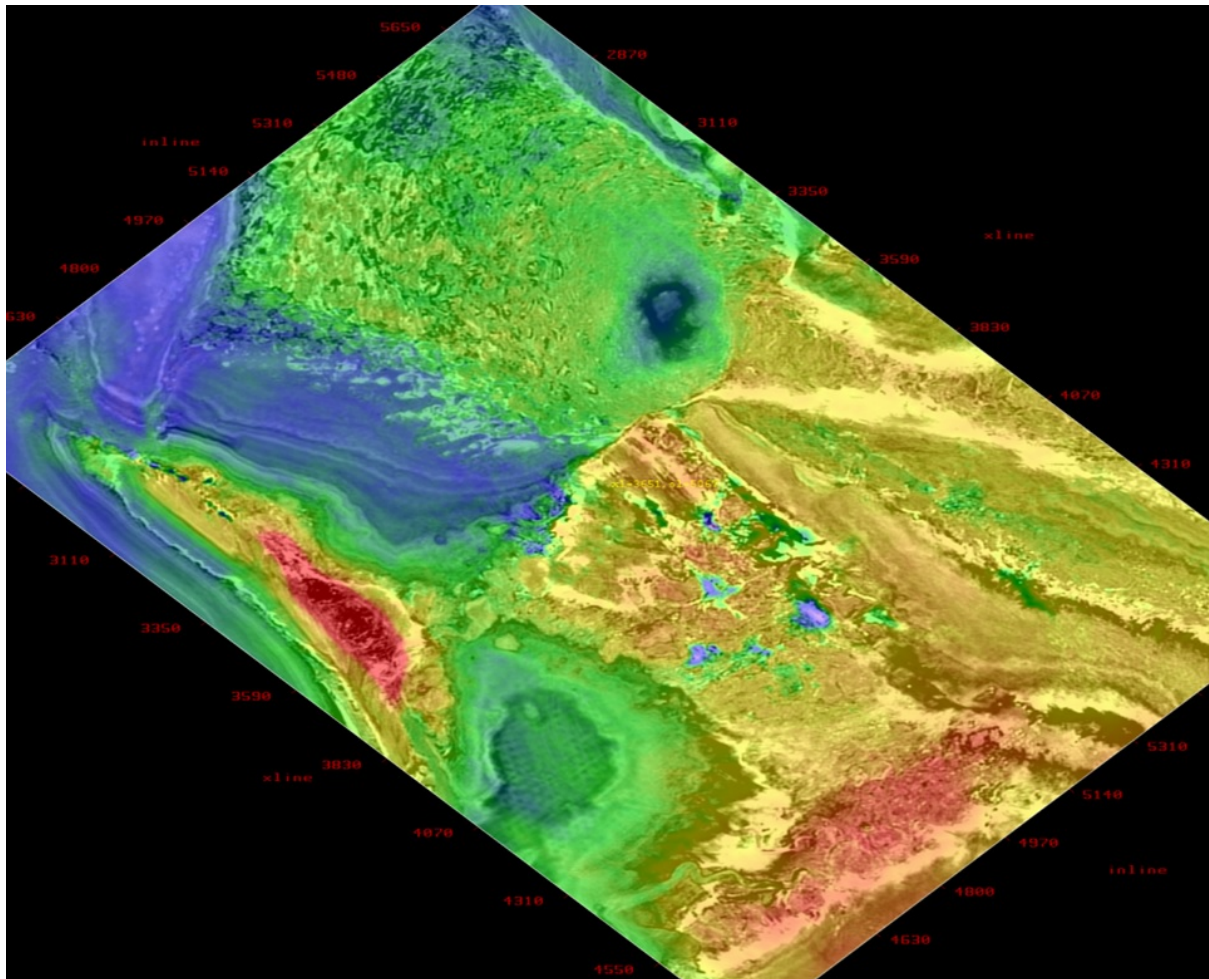
CGG continues to further refine the FWI processing flow, and has developed methods to reduce the artefacts and velocity errors associated with cycle skipping, whereby the algorithm converges on a local rather than global solution. Cycle skipping can be reduced in two ways: adaptive data selection automatically derives the most suitable offset range and mute parameters without requiring time-consuming manual input, while a probabilistic QC technique helps guide the choice of starting velocity model.

In addition to velocity, FWI can also assist with the derivation of other seismic parameters. Anisotropy (VTI or TTI) is needed for most real-world examples and, as such, is included in the modelling of FWI. But now a joint update of velocity and epsilon together can be performed, thereby updating the anisotropy. Also, a high-resolution FWI velocity model can better constrain the area of analysis and convergence of Q tomography, providing superior imaging results.

CGG's pivotal role in the continued development of FWI was recognized in this year's SEG awards. Andrew Ratcliffe, Vetle Vinje, Caroline Win and Graham Conroy of CGG have been distinguished with the Best Paper in *GEOPHYSICS* Award for their technical paper entitled 'Anisotropic 3D full-waveform inversion'. The paper was co-authored with Michael Warner, Tenice Nangoo, Joanna Morgan, Adrian

Umpleby, Nikhil Shah, Ivan Štekl, Lluís Guasch of Imperial College, London and Alexandre Bertrand of Conoco Phillips Norge and published in Volume 78, No.2, March-April 2013 of *GEOPHYSICS*.

For further insights into the latest highlights and developments in FWI, attend CGG booth #1339 at 11.15am for a presentation by Andrew Ratcliffe. There are also several CGG papers on FWI in the remaining SEG technical sessions. Full details are available at [cgg.com/seg2014](http://cgg.com/seg2014).



*FWI velocity models contain stunning detail and resolution, as seen within this depth slice from a broadband marine survey acquired using BroadSeis™, offshore Angola. (Image courtesy of CGG Data Library).*