High-frequency full waveform inversion for subsurface interpretation

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To improve our geological knowledge, we want to extract as much information as possible from our seismic data. Ever increasing compute power, in combination with better seismic data, enables us to develop better tools and to utilise better physics to build models of the subsurface. Full waveform inversion (FWI) is one approach which utilises the entire seismic wavefield to build a refined, high-resolution Earth model. Its use is well established as part of the depth model building workflow to improve imaging velocities. However, in this context it is often only the lower frequencies that are used.

High-frequency FWI attempts to utilise the entire seismic bandwidth to deliver an interpretation product in a reduced timeline. It combines velocity model building and imaging in a single step, by producing a migrated image (matching the amplitudes) imprinted on the velocity model (matching the kinematics). Arguably, this will outperform the combination of low-frequency FWI for velocity model building followed by least-squares reverse time migration (LS-RTM), which only images primary reflections modelled by the Born approximation. FWI uses a more sophisticated forward model with better physics and less approximations. But of course, the type of wave equation being solved is also a variable. Incorporating more physics within the FWI implementation combined with modern supercomputer facilities promises to increase the focus on very high frequency FWI in the coming years.

Through a series of field examples (Figure 1), we illustrate the meaning, applications and rewards of high frequency FWI in terms of qualitative interpretation. Quantitative interpretation is also considered with a comparison between the results of FWI and more conventional AVA inversion.

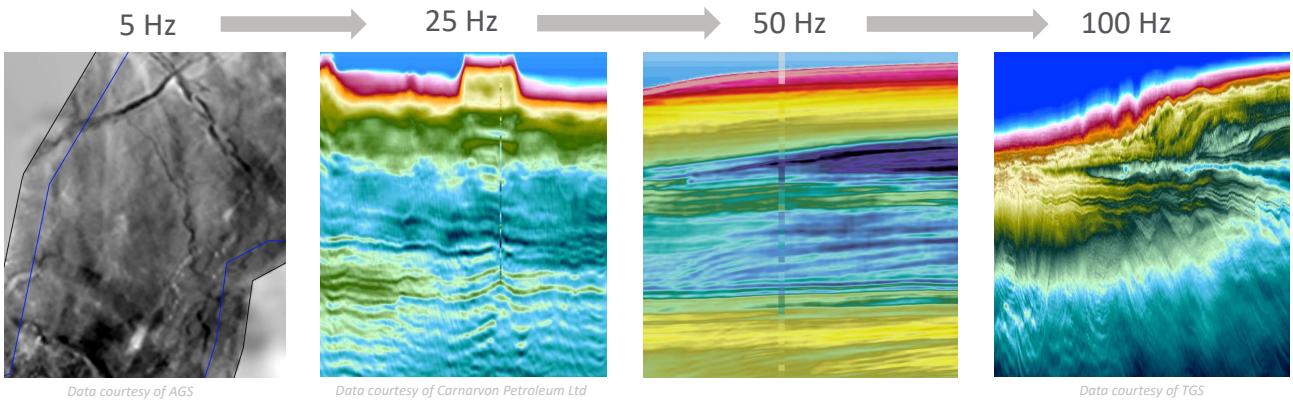

Figure 1. Example FWI models – from resolving shallow channels to improve imaging to producing high-resolution interpretation product

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