DATA SHEET

Q Imaging

Q Tomography, Q FWI, and Q Migration

Attenuation: Q

Q is the seismic Quality factor: a higher Q value means that we have less amplitude decay. Hence energy loss is inversely proportional to Q. However, the overall loss of energy in a propagating wavefront is contributed to by various unrelated mechanisms, such as:

- → Small-scale scattering (resulting in loss of higher frequencies)
- → interbed multiples (waveguide effects preventing energy from penetrating further into the earth)
- → intrinsic attenuation (a form of frictional heat loss removing energy from the wavefront)

The overall effect gives rise to what is known as the 'effective Q' and this is what we are working with in data processing. As can be imagined, it is very difficult to separate the effects of the individual attenuative mechanism to isolate the intrinsic Q value for a given rock.

One of the keys to a successful exploration or development program is the ability to resolve the target. However, the attenuating nature of the Earth causes the loss of energy in a seismic wave as it travels outward from its source point. The ensuant amplitude decay is proportional to both travel-time and to frequency: this not only leads to a decrease in seismic amplitude, but also changes the frequency content and phase of the recorded seismic signal. By correctly compensating for these effects within the migration scheme we can broaden the bandwidth of the data, balance amplitude behavior, correct dispersive phase change, and improve the resolution of stratigraphic features. However, achieving this requires a detailed Q model: such models can be derived using either ray-based or wave-based inversion schemes.

Q Tomography

ION's ray-based Q tomography leverages pre-stack migrated common image gathers for estimating Q, and has two alternative methods: log spectral ratio and centroid frequency shift. This robust Q tomography approach is designed to deal with spatially variant effects and works in concert with our suite of Q migration algorithms. In Figure 1 is shown a shallow water North Sea example, where highly absorptive near surface gas-charged sand channels degrade the deeper image. Following tomographic derivation of the Q model, a 200 Hz broadband seismic image is significantly improved using visco-acoustic (Q) Kirchhoff preSDM.

Q Full Waveform Inversion

For higher resolution model building, or direct attribute interpretation, Q-FWI offers a good solution. Our FWI algorithms can invert jointly for both TTI velocity and Q. Figure 2 shows a smooth starting Q model and the Q perturbation derived by FWI for a deep water West African example: here Q values of about 20 are recovered within a series of thin, compartmentalized, gas charged reservoirs.

BENEFITS OF Q IMAGING

- → Higher resolution amplitude balanced, improved subsurface images, especially with broadband, de-ghosted data
- → Reservoir Characterization – the Q attribute can be used directly to aid interpretation

Q Migration

ION's Q migration algorithms have been efficiently designed for visco-acoustic propagation that take into account the spatial variation of Q within the subsurface and yield high fidelity amplitude balanced images. Both our Kirchhoff and RTM algorithms accommodate Q.

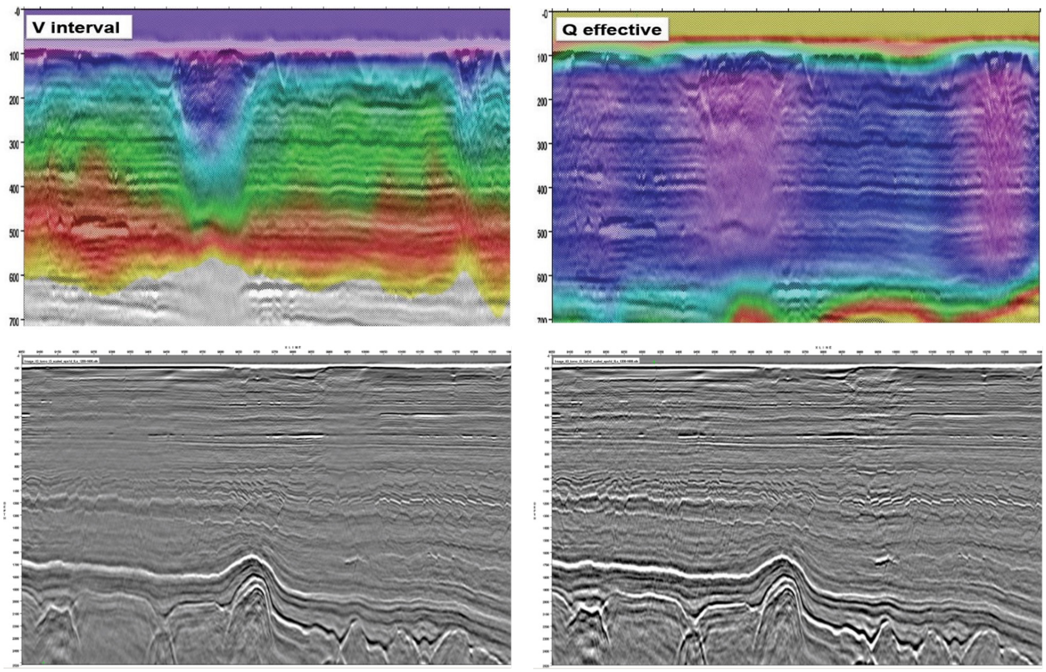

Figure 1. Top left: shallow section from a tomographic velocity model of North Sea broadband data. Top right: Q tomography highlights low Q (high attenuation) zones that need to be accounted for to optimize target resolution. Bottom left: broadband 200 Hz conventional Kirchhoff preSDM; Bottom right visco-acoustic (Q) preSDM (data courtesy of Polarcus).

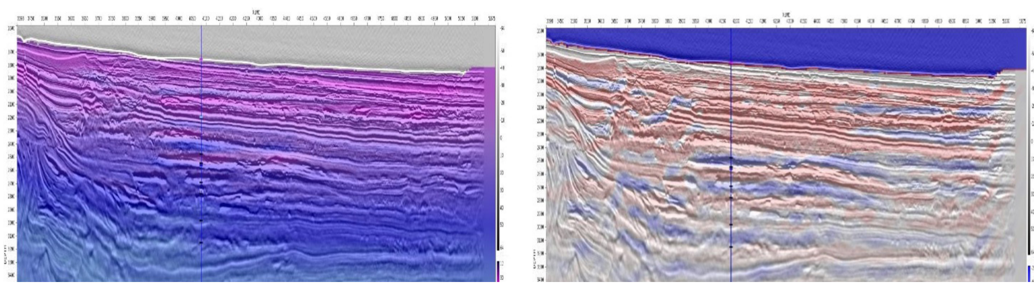

Figure 2. Deep water example, offshore West Africa. Left: smooth initial Q model. Right FWI Q inversion update, showing Q difference from initial model. The reservoir is clearly visible as a blue layer (with Q ~ 20) about halfway down the section around the well location, denoted by the vertical line (data courtesy of Ophir Energy).

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