

## A Game Changer Approach

Velocity is a key to clear seismic image and reliable time to depth conversion. In 90% of cases companies use 2D/3D CDP marine seismic acquisition to obtain both structural image and a velocity model. Unfortunately, based on overall experience, CDP velocities fall within  $\pm 15\text{-}20\%$  of the true velocities. In complex geological environments (salts, basalts, irregular bedding, high-velocity formations and so called “gas chimneys”) CDP velocity field tends to be even less reliable. As a result, unsuccessful drilling continues to be the major source of concern.

Full Waveform Inversion (FWI) is a game changer approach for velocity model building. It uses two-way wave equation and performs forward modeling to compute the difference between the acquired seismic data and the current model. As a result, high-fidelity velocity model that misses all the drawbacks typical for CDP velocity analysis and traveltome tomography is derived. FWI approach has potential to become a key tool to interpret seismic data acquired in complex geological settings and grow into a new standard for velocity model building.

For superior implementation of FWI you are only limited by:

- presence of low frequencies and quality of seismic impulse;
- presence of long offsets being enough to image target horizons.

## Limits on Offset Length

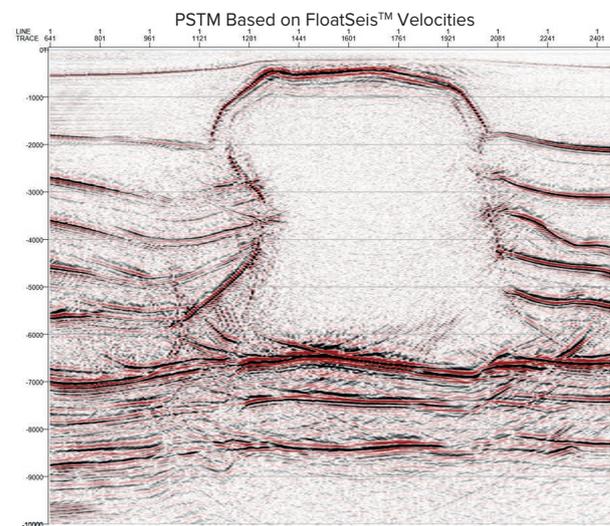
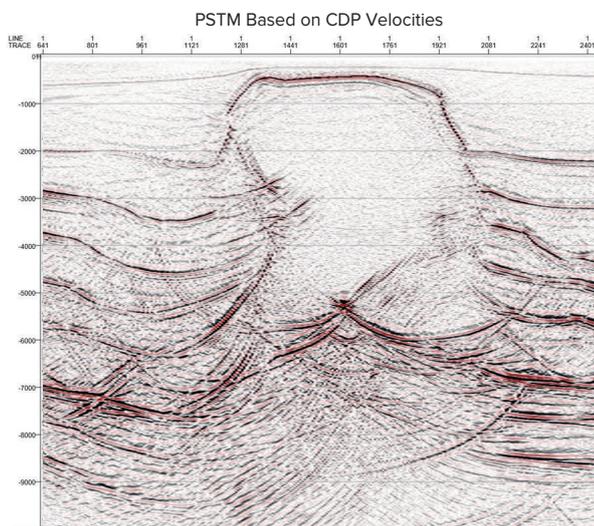
The existing stipulation is that the lack of long offset data can negatively influence FWI in terms of illuminating more subsurface angles and deeper sections. FWI reveals its potential by using both wave fields: reflection and refraction. Refraction waves for application in FWI requires recording arrays with length of approximately 5 to 6 times the depth of imaging (in complex geological environments it can bump up to 10-15 times). Thus, to be able to utilize FWI for depth up to 7 km depth, efficient recording of 40-60 km offsets is needed. Present-day marine seismic equipment offers a 12 km streamer length, and longer offset recording is difficult and expensive. A different concept on recording long offset data is required.

## Missing Low Frequencies

The need to use a low-frequency component of the seismic signal is dictated by the following factors:

- Increase in the signal-to-noise ratio at ultra-long distances;
- Full Waveform Inversion’s (FWI) application requires low frequency components to ensure a robust solution.

Low frequencies below 10 Hz are generally missing on conventional seismic records. The lack of low frequencies may be resolved with either well log information (dense grid of wells with a proper log data is required, that is not available for the majority of offshore areas) or by low frequency spectra emission during seismic data acquisitions (special low frequency source is required).



Seismic streamer data used for CDP velocity model building is not able to provide us with a proper image of the sub-salt formations (on the left). Ultra-long offset low frequency data used for FWI velocity model building routine helped to reconstruct the bottom of the salt body and gave us the clear image of sub-salt layers as well (on the right).