Lower crustal structures at Rockall Trough (West of Ireland) by Full waveform inversion

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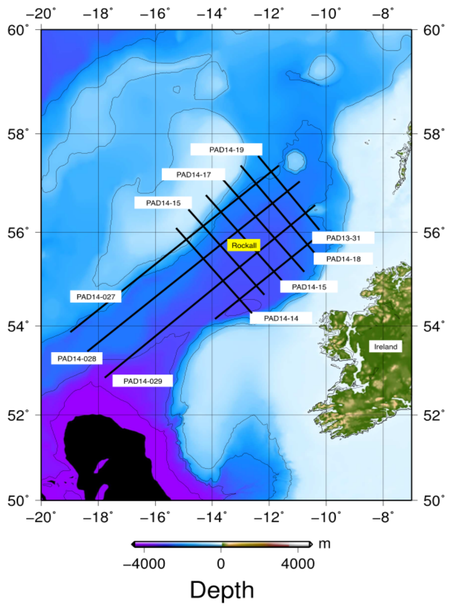
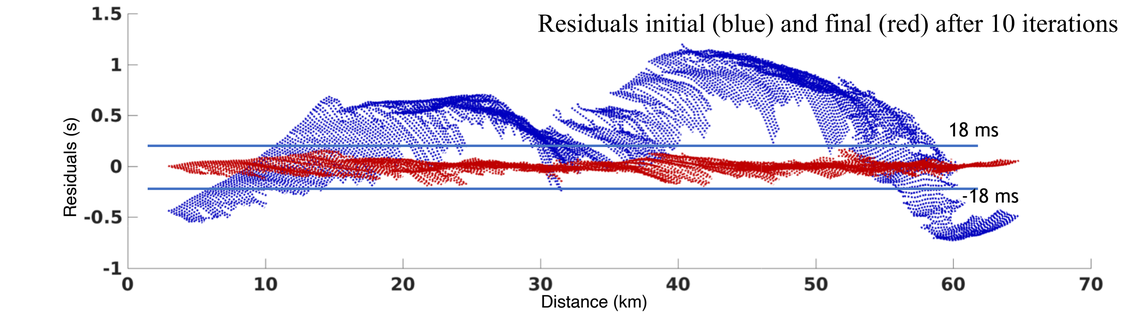
Introduction

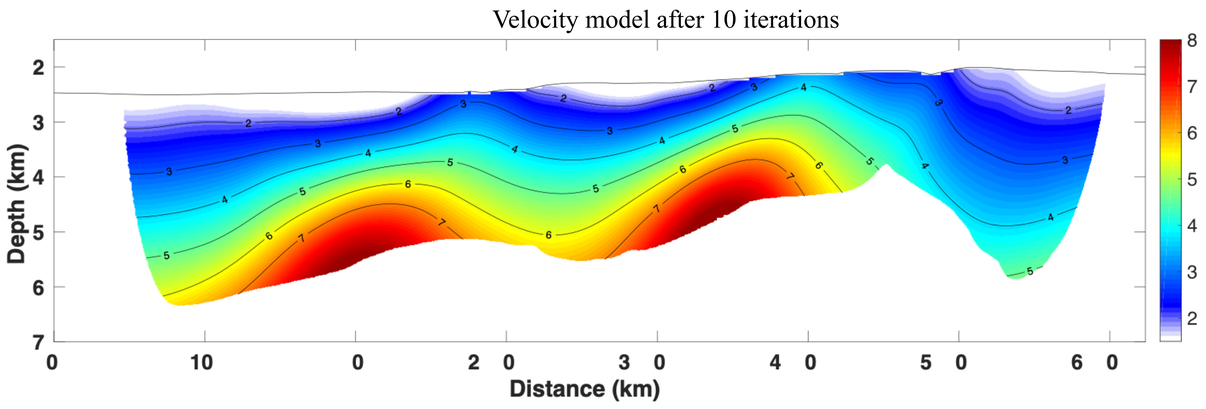
Rockall trough lies to the west of Ireland in NE Atlantic, it has a complex geology and has been debated for controversial geology for more than two decades. We have performed Full waveform inversion (FWI) on 2D seismic data set that is recorded in 2013-14 by using 10 km long streamer, this 2D seismic line is situated near the North-West margin in the Rockall Bank area. Full waveform inversion (FWI) is a powerful technique for obtaining elastic properties of the sub-surface from the seismic data. FWI provides properties of the sub-surface at the scale of the wavelength of the data set. We used travel time tomography on downward extrapolated data set to obtain a smooth starting velocity model for FWI. Downward continuation is a technique that enhances the first arrival and also reduces the computation time for forward modelling in FWI. The velocity model obtained from refraction travel time tomography, indicates the velocity from 1.6-4 km/s for the sediments and we have also observed very high velocity ~ 6-7.5 km/s just 3 km below sea-floor. We have performed FWI using these TTT velocity model as a starting model and inverted the refractions along with the wide angle reflections in the frequency range of 3-10 hz. FWI results gives the velocity of 6-7.2 km/s as well as defines geological structures that can be seen in the migrated seismic section. These high velocity structures could be a part of the continental crust and/or lower oceanic crustal igneous rocks like Gabbros.

Location of Rockall Trough and acquisition lines (in black)

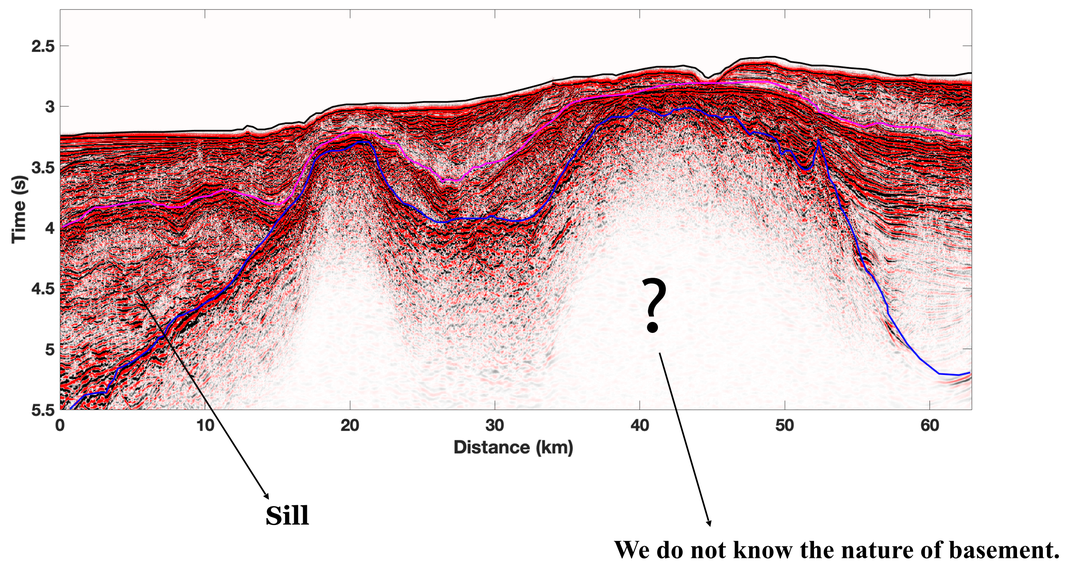


First arrival travel time tomography velocity model model

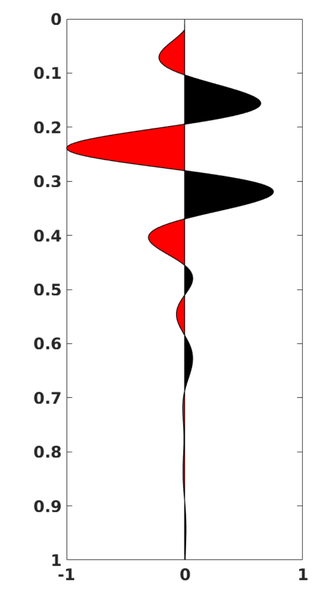




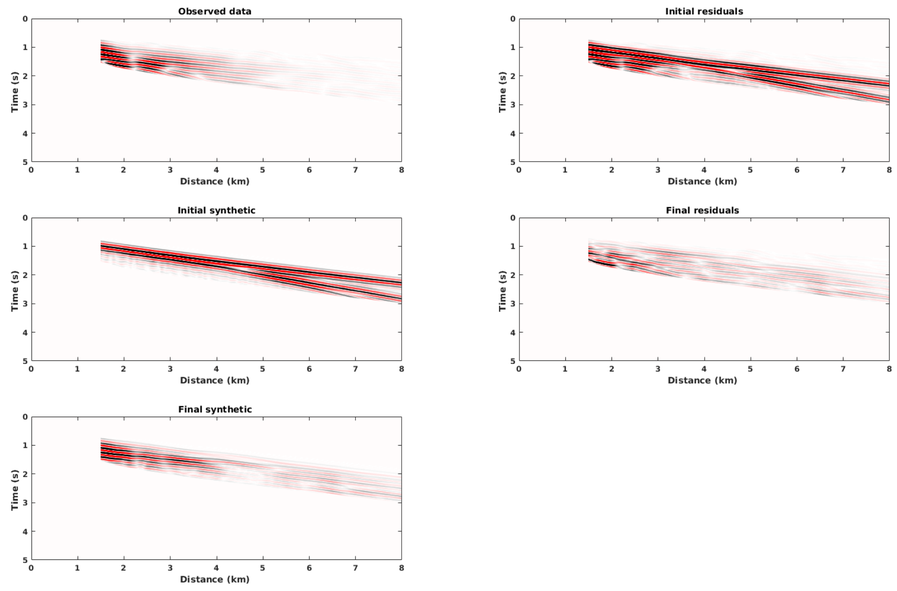
PSTM section of line PAD014-027 (shown in the map)



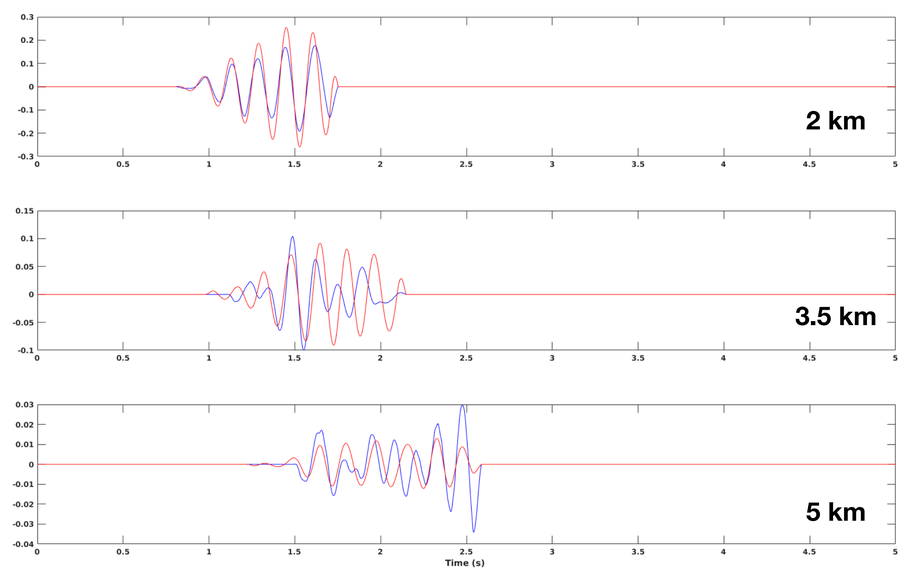
Full waveform inversion of refraction only (between 3-7 Hz)



Source used for FWI (3-7 Hz).



Inversion of one shot gather 12880, observed and synthetic data; initial and final residuals plotted at the same scale.



Observed (red) and synthetic (blue) traces of shot gather 12880.

Full waveform inversion (FWI) method

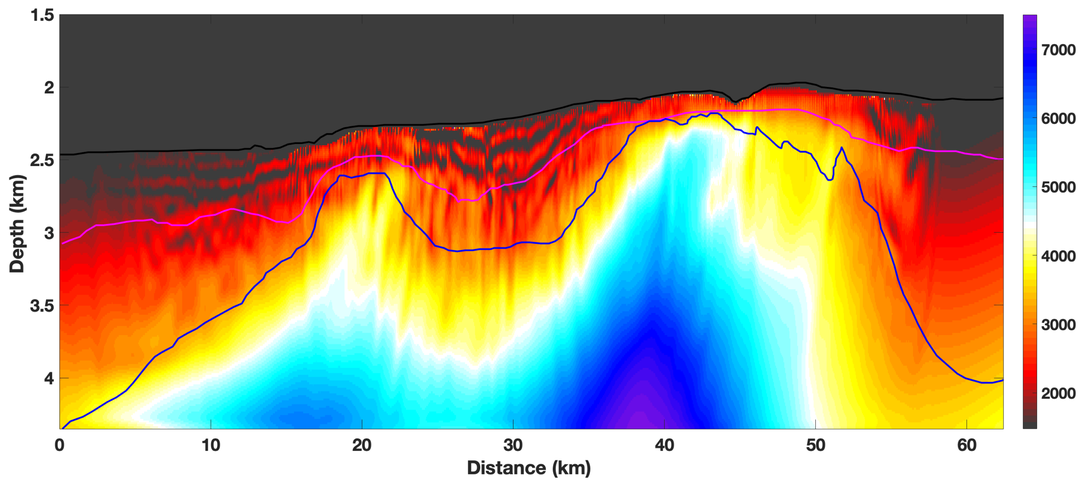
The elastic FWI is iterative method that seeks to minimise a least-square misfit function S between observed d_{obs} and synthetic d_{syn} data (Shipp & Singh 2002).

$$S = \sum_{\text{shots}} \int_0^T \mathrm{d}t \sum_{\text{recs}} [d_{\text{syn}} - d_{\text{obs}}]^2,$$

Thus, the misfit is measured quantitatively by taking, sample by sample, the least squared difference between the two datasets (pressure recordings in our case) for every receiver in each of the shot gathers.

Then we use conjugate gradient method to solve the iterative inversion problem.

Preliminary results of FWI (Velocity model after 30 iterations between frequency of 3-13 hz)



Conclusions and Perspectives

- First arrival travel time tomography was performed to obtain the initial velocity model for FWI. The velocity model was obtained with the uncertainty of 18 ms. We obtained very high velocity structures ~7 km/s just ~3 km below the sea-floor.
- FWI is performed on the downward continued data in the frequency range of 3-7, 3-10 and 3-13 Hz, we have inverted the full wavefield of refractions of every 2nd shot. The velocity model shows some structures that follows with the migrated image of seismic data.
- These high velocity structures could be the lower crustal igneous rocks like Gabbros.

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