Geophysical Research Abstracts
Vol. 18, EGU2016-11861, 2016
EGU General Assembly 2016

Next-generation seismic experiments: wide-angle, multi-azimuth, three-dimensional, full-waveform inversion

Rebecca Bell, Joanna Morgan, and Michael Warner
Imperial College London, United Kingdom (rebecca.bell@imperial.ac.uk)

There are many outstanding plate-tectonic scale questions that require us to know information about sub-surface physical properties, for example ascertaining the geometry and location of magma chambers and estimating the effective stress along plate boundary faults. These important scientific targets are often too deep, impractical and expensive for extensive academic drilling.

Full-waveform inversion (FWI) is an advanced seismic imaging technique that has recently become feasible in three dimensions, and has been widely adopted by the oil and gas industry to image reservoir-scale targets at shallow-to-moderate depths. In this presentation we explore the potential for 3-D FWI, when combined with appropriate marine seismic acquisition, to recover high-resolution high-fidelity P-wave velocity models for sub-sedimentary targets within the crystalline crust and uppermost mantle.

Using existing geological and geophysical models, we construct P-wave velocity models over three potential sub-sedimentary targets: the Soufrière Hills Volcano on Montserrat and its associated crustal magmatic system, the downgoing oceanic plate beneath the Nankai subduction margin, and the oceanic crust-uppermost mantle beneath the East Pacific Rise mid-ocean ridge. We use these models to generate realistic multi-azimuth 3-D synthetic seismic data, and attempt to invert these data to recover the original models. We explore the resolution and accuracy, sensitivity to noise and acquisition geometry, ability to invert elastic data using acoustic inversion codes, and the trade-off between low frequencies and starting velocity model accuracy.

We will show that FWI applied to multi-azimuth, refracted, wide-angle, low-frequency data can resolve features in the deep crust and uppermost mantle on scales that are significantly better than can be achieved by any other geophysical technique, and that these results can be obtained using relatively small numbers (60-90) of ocean-bottom receivers combined with large numbers of air-gun shots. We demonstrate that multi-azimuth 3-D FWI is robust in the presence of noise, that acoustic FWI can invert elastic data successfully, and that the typical errors to be expected in starting models derived using travel times will not be problematic for FWI given appropriately designed acquisition. In this presentation we will also discuss a recent field-example of the use of FWI to image the Endeavour spreading centre in the northeastern Pacific. FWI is a rapidly maturing technology; its transfer from the petroleum sector to tackle a broader range of targets now appears entirely achievable.