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Where no wave has gone before: unconventional elastic wave fields in exotic regimes

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Nowadays, elastic wave fields are acquired on land, at the sea or or within tunnels and boreholes. The increasing availability of computational resources allow to use their full information content, e.g., P- and S-waves, converted waves, guided and interface waves, to image geological discontinuities and/or to reconstruct multi-parameter models. For the full consideration of elastic wave propagation effects the efficient forward simulation in 3-D complex media gains in importance. Full wave field modelling is essential for seismic imaging and inversion but also to invent and verify new seismic reconstruction techniques. Innovative seismic methods sometimes use unconventional elastic wave fields having very specific properties and being the only solution for some exotic applications. Such unconventional elastic wave fields, for example, are exploited for the seismic prediction ahead of tunnels. Tunnel surface-waves that arrive at the front face of the tunnel are converted into body-waves. Reflected body-waves are later back-converted into tunnel surface-waves. Imaging methods based on these wave fields can successfully detect geological discontinuities ahead. The conversion of interface waves and body waves can also be observed in fluid-filled boreholes and can be used for seismic prediction while drilling. Other unconventional waves in an exotic regime are marine Scholte waves that can be excited by airguns. Scholte waves are interface waves propagating along the sea floor and can be used to reconstruct the shear-wave velocity of shallow water marine sediments - an important parameter to characterize the stability of the marine sediments for offshore constructions.

The ultimative goal, however, is the consistent consideration of both unconven¬tional waves as well as all other possible elastic wave propagation effects by full waveform inversion (FWI). Over the last several years, computer resources have brought 3D elastic FWI computations within reach. Some early acoustic field-scale applications have been spectacularly successful, appearing to justify the earlier optimism of Albert Tarantola and others in the 1980s. FWI is currently generating significant interest and excitement in the industrial and academic geophysics communities. The potential of full waveform inversion will be discussed with 2-D and 3-D applications using field and synthetic data.