CLAIMS

1. A method for computing images of a subterranean formation to be carried out by a computer system that includes one or more processors and one or more data-storage devices, the method comprising:

calculating a down-going source wavefield from a pressure wavefield measured on a source acquisition surface towed by a seismic exploration vessel;

decomposing a pressure wavefield measured on a receiver acquisition surface towed by the vessel into an up-going pressure wavefield and a down-going pressure wavefield; and

computing an image of the subterranean formation based on the down-going source wavefield combined with the down-going pressure wavefield and the up-going pressure wavefield.

2. The method of claim 1, wherein calculating the down-going source wavefield from the pressure wavefield comprises:

calculating notional source signatures from near-field pressure recordings; and

transforming the notional source signatures from a space-time domain to a wavenumber-frequency domain, wherein each notional source signature is associated with an element of a seismic source towed by the vessel.

3. The method of claim 1, wherein decomposing the pressure wavefield comprises:

transforming the measured pressure wavefield and the normal velocity wavefield from a space-time domain to a wavenumber-frequency domain;

calculating the up-going pressure wavefield as a function of the pressure and normal velocity wavefields in the wavenumber-frequency domain; and

calculating the down-going pressure wavefield as a function of the pressure and normal velocity wavefields in the wavenumber-frequency domain.

4. The method of claim 1, wherein calculating the down-going source wavefield from the pressure wavefield includes:

constraining the calculation of notional source signatures based on the measured source wavefield at the source acquisition surface.

5. The method of claim 1, wherein computing a first image of the subterranean formation based on the down-going source wavefield and the up-going pressure wavefield comprises:

for each depth level:

extrapolating the down-going source wavefield and the up-going pressure wavefield to a depth level;

transforming the down-going source wavefield and the up-going pressure wavefield from the wavenumber-frequency domain to the space-frequency domain; and

calculating image values using an imaging condition.

6. The method of claim 1, wherein computing a second image of the subterranean formation based on the up-going and down-going pressure wavefields comprises:

for each depth level:

extrapolating the up-going and down-going pressure wavefields to a depth level;

transforming from the wavenumber-frequency domain to the space-frequency domain; and

calculating image values using an imaging condition.

7. A computer-readable medium having machine-readable instructions encoded thereon for enabling one or more processors of a computer system to perform the operations of

calculating a down-going source wavefield from a pressure wavefield measured on a source acquisition surface towed by a seismic exploration vessel;

decomposing a pressure wavefield measured on a receiver acquisition surface towed by the vessel into an up-going pressure wavefield and a down-going pressure wavefield; and

calculating an image of the subterranean formation as a function of the down-going source wavefield, the up-going pressure wavefield, and the down-going pressure wavefield.

8. The computer-readable medium of claim 7, wherein calculating the down-going source wavefield from the pressure wavefield includes:

constraining the calculation of notional source signatures based on the measured source wavefield at the source acquisition surface.

9. The computer-readable medium of claim 7, wherein calculating the down-going source wavefield from the pressure wavefield comprises:

calculating notional source signatures from the near-field pressure recordings; and

transforming the notional source signatures from a space-time domain to a wavenumber-frequency domain, wherein each notional source signature is associated with an element of a seismic source towed by the vessel.

10. The computer-readable medium of claim 7, wherein decomposing the pressure wavefield and the normal velocity wavefield comprises:

transforming the measured pressure wavefield and a normal velocity wavefield measured on the receiver acquisition surface from a space-time domain to a wavenumber-frequency domain;

calculating the up-going pressure wavefield as a function of the pressure and normal velocity wavefields in the wavenumber-frequency domain; and

calculating the down-going pressure wavefield as a function of the pressure and normal velocity wavefields in the wavenumber-frequency domain.

11. The computer-readable medium of claim 7, wherein calculating an image of the subterranean formation comprising:

computing a first image of the subterranean formation based on the down-going source wavefield and the up-going pressure wavefield;

computing a second image of the subterranean formation based on the up-going and down-going pressure wavefields; and

adding the first image and the second image to form the image of the subterranean formation.

12. The computer-readable medium of claim 11, wherein computing the first image of the subterranean formation based on the down-going source wavefield and the up-going pressure wavefield comprises:

for each depth level:

extrapolating the down-going source wavefield and the up-going pressure wavefield to a depth level;

transforming the down-going source wavefield and the up-going pressure wavefield from the wavenumber-frequency domain to the space-frequency domain; and

calculating image values using an imaging condition.

13. The computer-readable medium of claim 11, wherein computing the second image of the subterranean formation based on the up-going and down-going pressure wavefields comprises:

for each depth level:

extrapolating the up-going and down-going pressure wavefields to a depth level;

transforming the from the wavenumber-frequency domain to the space-frequency domain; and

calculating image values using an imaging condition.

14. A system for measuring wavefields in fluid volume, the system comprising:

a seismic source to be connected to a vessel and towed below a free surface of a fluid volume;

a source acquisition surface to be connected to the vessel and towed beneath the source to measure pressure wavefields generated by the source; and

a receiver acquisition surface to be connected to the vessel and towed behind the source acquisition surface to measure pressure and normal velocity wavefields associated with the pressure wavefields generated by the source.

15. The system of claim 14, wherein the source acquisition surface comprises one or more source streamers, each source streamer having one or more pressure sensors distributed along the length of the source streamer.

16. The system of claim 15, wherein the source acquisition surface further comprises a transverse data transmission cable having a first end connected to a first source data transmission cable and a second end connected to a second data transmission cable, wherein the source streamers are connected to the transverse data transmission cable and the source data transmission cables are connected to the vessel.

17. The system of claim 15, wherein the source acquisition surface further comprises one or more transverse cables connected to the source streamers.

18. The system of claim 15, wherein the source streamers are weighted to form a curved source acquisition surface.

19. The system of claim 15, wherein the source streamers have approximately the same weight to place the source streamers at approximately the same depth.

20. The system of claim 15, wherein each source streamer further comprises one or more depth controllers to control the depth and position of the source streamer.

21. The system of claim 15, wherein the source streamers are crossed.

22. The system of claim 14, wherein the source acquisition surface to be connected to the vessel and towed beneath the source further comprises a single streamer towed beneath the source to measure a down-going source wavefield and one or more streamers towed to a first side of the source and one or more streamers towed to a second side of the source located opposite the first side, the one or more streamers to measure down-going and horizontally propagating wavefields.