

CLAIMS

1. A method to generate an image of a subterranean formation using a programmable computer programmed to at least perform the operations of:

recording pressure wavefield samples of a pressure wavefield measured with pressure sensors at a sample rate between a Nyquist rate and one half of the Nyquist rate;

recording acceleration wavefield samples of a particle motion wavefield with particle motion sensors at the sample rate;

interpolating a pressure wavefield in a time domain based on the pressure wavefield samples and the acceleration wavefield samples;

filtering the pressure wavefield and interpolated pressure wavefield to obtain an up-going pressure wavefield; and

generating an image of a subterranean formation based at least in part on the up-going pressure wavefield.

2. The method of claim 1, wherein one half of the Nyquist rate is a lower bound for the pressure wavefield samples alone.

3. The method of claim 2, wherein the sample rate is less than the Nyquist rate and is greater than one half of the Nyquist rate.

4. The method of claim 1, further comprises calculating the acceleration wavefield

samples as time derivatives of vertical velocity wavefield samples of a vertical velocity wavefield measured with a particle motion sensor sampled at the sample rate.

5. The method of claim 1, wherein interpolating the pressure wavefield in the time domain further comprises interpolating the pressure wavefield as a function of the pressure wavefield samples and time derivatives of vertical velocity wavefield samples, wherein the time derivatives of the vertical velocity wavefield samples are the acceleration wavefield samples.

6. The method of claim 1, wherein the pressure sensor and the particle motion sensor are collocated in a streamer.

7. The method of claim 1, wherein interpolating the pressure wavefield in the time domain further comprises calculating the pressure wavefield as a function of the pressure wavefield samples and the acceleration wavefield samples as a sum of time derivatives of velocity wavefield samples measured at the sample rate with three orthogonal particle motion sensors.

8. A system to generate an image of a subterranean formation, the system comprising:

one or more processors;

one or more data-storage devices; and

a routine stored in one or more of the one or more data-storage devices and executed by the one or more processors, the routine directed to:

retrieving pressure wavefield samples recorded in the one or more data-storage devices at a sample rate between a Nyquist rate and one half of the Nyquist rate;

retrieving acceleration wavefield samples recorded in the one or more data-storage devices at the sample rate;

interpolating a pressure wavefield in a time domain based on the pressure wavefield samples and the acceleration wavefield samples;

filtering the pressure wavefield and interpolated pressure wavefield to obtain an up-going pressure wavefield; and

generating an image of a subterranean formation based at least in part on the up-going pressure wavefield.

9. The system of claim 8, wherein one half of the Nyquist rate is a lower bound for the pressure wavefield samples alone.

10. The system of claim 9, wherein the sample rate is less than the Nyquist rate and is greater than half the Nyquist rate.

11. The system of claim 8, further comprises calculating the acceleration wavefield samples as time derivatives of vertical velocity wavefield samples of a vertical velocity wavefield measured with a particle motion sensor sampled at the sample rate.

12. The system of claim 8, wherein interpolating the pressure wavefield in the time domain further comprises interpolating the pressure wavefield as a function of the pressure wavefield samples and time derivatives of the vertical velocity wavefield samples, wherein the time derivatives of the vertical velocity wavefield samples are the acceleration wavefield samples.

13. The system of claim 8, further comprises receiving the pressure wavefield samples, receiving the particle motion wavefields, and interpolating the pressure wavefield in near-real time on board a survey vessel.

14. The system of claim 8, wherein interpolating the pressure wavefield in the time domain further comprises calculating the pressure wavefield as a function of the pressure wavefield samples and the acceleration wavefield samples as a sum of time derivatives of velocity wavefield samples measured at the sample rate with three orthogonal particle motion sensors.

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

receiving pressure wavefield samples of a pressure wavefield measured by pressure sensors located in a streamer at a sample rate between a Nyquist rate and one half of the Nyquist rate;

receiving acceleration wavefield samples measured by particle motion sensors at the sample rate;

interpolating a pressure wavefield in a time domain based on the pressure wavefield samples and the acceleration wavefield samples;

filtering the pressure wavefield and interpolated pressure wavefield to obtain an up-going pressure wavefield; and

generating an image of a subterranean formation based at least in part on the up-going pressure wavefield.

16. The medium of claim 15, wherein one half of the Nyquist rate is a lower bound for the sample rates the pressure wavefield samples alone.

17. The medium of claim 16, wherein the sample rate is less than the Nyquist rate and is greater than one half of the Nyquist rate.

18. The medium of claim 15, wherein interpolating the pressure wavefield in the time domain further comprises calculating the acceleration wavefield samples as time derivatives of vertical velocity wavefield samples of a vertical velocity wavefield measured with a particle motion sensor sampled at the sample rate.

19. The medium of claim 15, wherein interpolating the pressure wavefield in the time domain further comprises interpolating the pressure wavefield as a function of the pressure wavefield samples and time derivatives of the vertical velocity wavefield

samples, wherein the time derivatives of the vertical velocity wavefield samples are the acceleration wavefield samples.

20. The medium of claim 15, wherein interpolating the pressure wavefield in the time domain further comprises calculating the pressure wavefield as a function of the pressure wavefield samples and the acceleration wavefield samples as a sum of time derivatives of velocity wavefield samples measured at the sample rate with three orthogonal particle motion sensors.