CLAIMS

1. In a process for generating a seismic image of a subterranean formation using marine seismic techniques in which a source is activated above the subterranean formation and the reflections from the subterranean formation are recorded as pressure and vertical velocity data generated by receivers, the specific improvement comprising:

separating the recorded pressure data into up-going pressure data and down-going pressure data based on the recorded pressure data and the recorded vertical velocity data;

generating interpolated and regularized down-going pressure data at grid points of a migration grid based on the down-going pressure data;

generating interpolated and regularized up-going pressure data at grid points of the migration grid based on the up-going pressure data; and

generating a seismic image of the subterranean formation at grid points of the migration grid based on the interpolated and regularized down-going pressure data and the interpolated and regularized up-going pressure data, thereby enhancing the seismic image by revealing structures of the subterranean formation with attenuated noise and attenuated crosstalk artifacts.

2. The process of claim 1, wherein separating the pressure data into the up-going pressure data and the down-going pressure data further comprises:

transforming the recorded vertical velocity data from the space-time domain to the wavenumber-frequency domain;

extrapolating receiver coordinates of the recorded pressure data and the recorded vertical velocity data from receiver depth to a free surface level;

calculating down-going pressure data from the recorded pressure data and the recorded vertical velocity data; and

calculating up-going pressure data from the recorded pressure data and the recorded vertical velocity data.

3. The process of claim 1, wherein generating the interpolated and regularized down-going pressure data at grid points of the migration grid further comprises:

regularizing irregular receiver coordinates of the down-going pressure data to regularly spaced grid points of the migration grid; and

interpolating down-going pressure data at grid points of the migration from the down-going pressure data regularized to grid points of migration grid to generate interpolated and regularized down-going pressure data at grid points of the migration grid.

4. The process of claim 1, wherein generating the interpolated and regularized up-going pressure data at grid points of the migration grid further comprises:

regularizing irregular receiver coordinates of the up-going pressure data to regularly spaced grid points of the migration grid; and

interpolating up-going pressure data at grid points of the migration from the up-going pressure data regularized to grid points of migration grid to generate interpolated and regularized up-going pressure data at grid points of the migration grid.

5. The process of claim 1, wherein generating the seismic image of the subterranean formation further comprises for each grid point in the migration grid, calculating an image value of the seismic image based on the interpolated and regularized down-going pressure data and the interpolated and regularized up-going pressure data.

6. A system that generates a seismic image of a subterranean formation, the system comprising:

one or more processors;

one or more data-storage devices; and

machine-readable instructions stored in the one or more data-storage devices that when executed using the one or more processors controls the system to carry out the operations comprising:

separating recorded pressure data into up-going pressure data and down-going pressure data based on recorded pressure data and recorded vertical velocity data generated by receivers in a marine survey of the subterranean formation and stored in the one or more data-storage devices;

generating interpolated and regularized down-going pressure data at grid points of a migration grid based on the down-going pressure data;

generating interpolated and regularized up-going pressure data at grid points of the migration grid based on the up-going pressure data; and

generating a seismic image of the subterranean formation at grid points of the migration grid based on the interpolated and regularized down-going pressure data and the interpolated and regularized up-going pressure data, the seismic image revealing structures of the subterranean formation with attenuated noise and attenuated crosstalk artifacts.

7. The system of claim 6, wherein separating the pressure data into the up-going pressure data and the down-going pressure data further comprises:

transforming the recorded vertical velocity data from the space-time domain to the wavenumber-frequency domain;

extrapolating receiver coordinates of the recorded pressure data and the recorded vertical velocity data from receiver depth to a free surface level;

calculating down-going pressure data from the recorded pressure data and the recorded vertical velocity data; and

calculating up-going pressure data from the recorded pressure data and the recorded vertical velocity data.

8. The system of claim 6, wherein generating the interpolated and regularized down-going pressure data at grid points of the migration grid further comprises:

regularizing irregular receiver coordinates of the down-going pressure data to regularly spaced grid points of the migration grid; and

interpolating down-going pressure data at grid points of the migration from the down-going pressure data regularized to grid points of migration grid to generate interpolated and regularized down-going pressure data at grid points of the migration grid.

9. The system of claim 6, wherein generating the interpolated and regularized up-going pressure data at grid points of the migration grid further comprises:

regularizing irregular receiver coordinates of the up-going pressure data to regularly spaced grid points of the migration grid; and

interpolating up-going pressure data at grid points of the migration from the up-going pressure data regularized to grid points of migration grid to generate interpolated and regularized up-going pressure data at grid points of the migration grid.

10. The system of claim 6, wherein generating the seismic image of the subterranean formation further comprises for each grid point in the migration grid, calculating an image value of the seismic image based on the interpolated and regularized down-going pressure data and the interpolated and regularized up-going pressure data.

11. A non-transitory computer-readable medium encoded with machine-readable instructions to control one or more processors of a computer system to perform the operations comprising:

separating recorded pressure data into up-going pressure data and down-going pressure data based on recorded pressure data and recorded vertical velocity data generated by receivers in a marine survey of a subterranean formation and stored in the one or more data-storage devices;

generating interpolated and regularized down-going pressure data at grid points of a migration grid based on the down-going pressure data;

generating interpolated and regularized up-going pressure data at grid points of a migration grid based on the up-going pressure data; and

generating a seismic image of the subterranean formation at grid points of the migration grid based on the interpolated and regularized down-going pressure data and the interpolated and regularized up-going pressure data, the seismic image revealing structures of the subterranean formation with attenuated noise and attenuated crosstalk artifacts.

12. The medium of claim 11, wherein separating the pressure data into the up-going pressure data and the down-going pressure data further comprises:

transforming the recorded vertical velocity data from the space-time domain to the wavenumber-frequency domain;

extrapolating receiver coordinates of the recorded pressure data and the recorded vertical velocity data from receiver depth to a free surface level;

calculating down-going pressure data from the recorded pressure data and the recorded vertical velocity data; and

calculating up-going pressure data from the recorded pressure data and the recorded vertical velocity data.

13. The medium of claim 11, wherein generating the interpolated and regularized down-going pressure data at grid points of the migration grid further comprises:

regularizing irregular receiver coordinates of the down-going pressure data to regularly spaced grid points of the migration grid; and

interpolating down-going pressure data at grid points of the migration from the down-going pressure data regularized to grid points of migration grid to generate interpolated and regularized down-going pressure data at grid points of the migration grid.

14. The medium of claim 11, wherein generating the interpolated and regularized up-going pressure data at grid points of the migration grid further comprises:

regularizing irregular receiver coordinates of the up-going pressure data to regularly spaced grid points of the migration grid; and

interpolating up-going pressure data at grid points of the migration from the up-going pressure data regularized to grid points of migration grid to generate interpolated and regularized up-going pressure data at grid points of the migration grid.

15. The medium of claim 11, wherein generating the seismic image of the subterranean formation further comprises for each grid point in the migration grid, calculating an image value of the seismic image based on the interpolated and regularized down-going pressure data and the interpolated and regularized up-going pressure data.

16. A method to manufacture a geophysical data product, the method comprising:

obtaining pressure and vertical velocity data recorded in a marine survey of a subterranean formation;

separating the recorded pressure data into up-going pressure data and down-going pressure data based on the recorded pressure data and the recorded vertical velocity data;

generating interpolated and regularized down-going pressure data at grid points of a migration grid based on the down-going pressure data;

generating interpolated and regularized up-going pressure data at grid points of the migration grid based on the up-going pressure data;

generating a seismic image of the subterranean formation at grid points of the migration grid based on the interpolated and regularized down-going pressure data and the interpolated and regularized up-going pressure data; and

recording the seismic image on one or more non-transitory computer-readable media, thereby creating the geophysical data product.