

SUMMARY

[0015] Various embodiments described herein seek to address at least one of the problems and/or disadvantages discussed above. It is therefore a general aspect of the embodiments to provide a system and method for predicting surface multiples using surface inconsistent seismic data and without needing to perform a companion streamer survey.

[0016] According to a first aspect of the embodiments, a method for processing seismic data includes the steps of receiving seismic data which was generated using sources and receivers, performing seismic interferometry on the received seismic data to generate additional seismic data, and using the received seismic data and the additional seismic data to predict multiples in the received seismic data, wherein the received seismic data was generated using an Ocean Bottom Cable (OBC) system; and wherein the additional seismic data is one of: data that would have been recorded by the receivers, which are located on the ocean floor, if the receivers were instead located at the ocean surface or data that would have been recorded by the receivers on the ocean floor if the sources were also located on the ocean floor.

[0017] According to a second aspect of the embodiments, a system for processing seismic data includes a processor configured to receive seismic data which was generated using sources and receivers, and to perform seismic interferometry on the received seismic data to generate additional seismic data, wherein the processor uses the received seismic data and the additional seismic data to predict multiples in the received seismic data, wherein the received seismic data was generated using an Ocean Bottom Cable (OBC) system; and wherein the additional seismic data is one of: data that would have been recorded by the receivers, which are located on the ocean floor, if the receivers were instead located at the ocean surface or data that would have been recorded by the receivers on the ocean floor if the sources were also located on the ocean floor.

[0018] According to a third aspect of the embodiments, a computer-readable medium containing program instructions which, when executed on a suitably programmed computer processing device, perform the steps of: receiving seismic data which was generated using sources and receivers, performing seismic interferometry on the received seismic data to

generate additional seismic data; and using the received seismic data and the additional seismic data to predict multiples in the received seismic data, wherein the received seismic data was generated using an Ocean Bottom Cable (OBC) system; and wherein the additional seismic data is one of: data that would have been recorded by the receivers, which are located on the ocean floor, if the receivers were instead located at the ocean surface or data that would have been recorded by the receivers on the ocean floor if the sources were also located on the ocean floor.

CLAIMS

1. A method for processing seismic data comprising:
 - receiving seismic data which was generated using sources and receivers;
 - performing seismic interferometry on the received seismic data to generate additional seismic data; and
 - using the received seismic data and the additional seismic data to predict multiples in the received seismic data,wherein the received seismic data was generated using an Ocean Bottom Cable (OBC) system; and
 - wherein the additional seismic data is one of: data that would have been recorded by the receivers, which are located on the ocean floor, if the receivers were instead located at the ocean surface or data that would have been recorded by the receivers on the ocean floor if the sources were also located on the ocean floor.
2. The method of claim 1, wherein said sources and receivers are spaced apart depthwise by at least a predetermined distance.
3. The method of claim 1, wherein the step of performing seismic interferometry further

comprises:

cross-correlating recordings of wave fields at two receiver positions to generate a Green's function that would have been observed at one of the two receiver positions if there had been an impulsive source at the other one of the two receiver positions.

4. The method of claim 3, wherein the step of cross-correlating further comprises calculating:

$$\Re\{G(X_A, X_B, \omega)\} = \int_{\partial D} \frac{-1}{j\omega\rho(X)} (G^*(X_A, X, \omega) \partial_i G(X_B, X, \omega) - \partial_i G^*(X_A, X, \omega) G(X_B, X, \omega)) n_i d^2x$$

where R denotes the real part, G refers to Green's function, ρ refers to density, n refers to a normal direction of a boundary, j refers to $\sqrt{-1}$, ω refers to frequency; super script $*$ refers to the complex conjugate; X refers to locations and D refers to an enclosed boundary.

5. The method of claim 1, further comprising the step of:
removing the predicted multiples from the seismic data.

6. A system for processing seismic data comprising:

a processor configured to receive seismic data which was generated using sources and receivers, and to perform seismic interferometry on the received seismic data to generate additional seismic data;

wherein the processor uses the received seismic data and the additional seismic data to predict multiples in the received seismic data,

wherein the received seismic data was generated using an Ocean Bottom Cable (OBC) system; and

wherein the additional seismic data is one of: data that would have been recorded by the receivers, which are located on the ocean floor, if the receivers were instead located at the ocean surface or data that would have been recorded by the receivers on the ocean floor if the sources were also located on the ocean floor.

7. The system of claim 6, wherein said sources and receivers are spaced apart depthwise by at least a predetermined distance.

8. The system of claim 6, wherein the processor performs seismic interferometry further by cross-correlating recordings of wave fields at two receiver positions to generate a Green's function that would have been observed at one of the two receiver positions if there had been an impulsive source at the other one of the two receiver positions.

9. The system of claim 8, wherein the processor performs the cross-correlating by calculating:

$$R\{G(X_A, X_B, \omega)\} = \int_{\partial D} \frac{-1}{j\omega\rho(X)} (G^*(X_A, X, \omega) \partial_i G(X_B, X, \omega) - \partial_i G^*(X_A, X, \omega) G(X_B, X, \omega)) n_i d^2x$$

where R denotes the real part, G refers to Green's function, ρ refers to density, n refers to a normal direction of a boundary, j refers to $\sqrt{-1}$, ω refers to frequency; super script $*$ refers to the complex conjugate; X refers to locations and D refers to an enclosed boundary.

10. The system of claim 6, wherein the processor is further configured to remove the predicted multiples from the seismic data.

11. A computer-readable medium containing program instructions which, when executed on a suitably programmed computer processing device, perform the steps of:

receiving seismic data which was generated using sources and receivers;

performing seismic interferometry on the received seismic data to generate additional seismic data; and

using the received seismic data and the additional seismic data to predict multiples in the received seismic data,

wherein the received seismic data was generated using an Ocean Bottom Cable (OBC) system; and

wherein the additional seismic data is one of: data that would have been recorded by the receivers, which are located on the ocean floor, if the receivers were instead located at the ocean surface or data that would have been recorded by the receivers on the ocean floor if the sources were also located on the ocean floor.

12. The computer-readable medium of claim 11, wherein said sources and receivers are spaced apart depthwise by at least a predetermined distance.

13. The computer-readable medium of claim 11, wherein the step of performing seismic interferometry further comprises:

cross-correlating recordings of wave fields at two receiver positions to generate a Green's function that would have been observed at one of the two receiver positions if there had been an impulsive source at the other one of the two receiver positions.

14. The computer-readable medium of claim 13, wherein the step of cross-correlating further comprises calculating:

$$\text{R}\{G(X_A, X_B, \omega)\} = \int_{\partial D} \frac{-1}{j\omega\rho(X)} (G^*(X_A, X, \omega) \partial_i G(X_B, X, \omega) - \partial_i G^*(X_A, X, \omega) G(X_B, X, \omega)) n_i d^2x$$

where R denotes the real part, G refers to Green's function, ρ refers to density, n refers to a normal direction of a boundary, j refers to $\sqrt{-1}$, ω refers to frequency; super script $*$ refers to the complex conjugate; X refers to locations and D refers to an enclosed boundary.