

CLAIMS

What is claimed is:

1. A method of seismic exploration above a region of subsurface
5 containing structural or stratigraphic features conducive to determining a presence, migration, or accumulation of hydrocarbons, the method comprising:
accessing at least a portion of a seismic source survey, wherein the seismic source survey corresponds to a seismic source excitation, wherein the seismic source excitation is produced by a seismic source, and wherein the at least a portion of a
10 seismic source survey comprises data corresponding to at least one time before a time of the seismic source excitation;
separating a coherent signal from the at least a portion of a seismic source survey via a combing and deblending operation, wherein the combing and deblending operation is an iterative operation configured to predict at least a portion of weak-
15 coherence signals caused by the seismic source excitation, and wherein the combing and deblending operation is based at least in part on a gather comprising the at least a portion of a seismic source survey corresponding to the at least one time before a time of the seismic source excitation;
recovering at least a portion of leaked or misallocated signals via an
20 attenuation of noise at least in part by allocating the noise to a time before the time of the seismic source excitation, wherein the leaked or misallocated signals are caused by a separation of primary signals; and
producing a receiver gather based on the separating and the coherent signal, wherein the receiver gather is a recording of multiple source excitations on a receiver,

and wherein the receiver gather is used in exploration for hydrocarbons within the region of the subsurface.

2. The method of claim 1, comprising:

5 determining a residual value;

in response to the residual value being less than or equal to a threshold,

outputting the coherent signal for use in the exploration for hydrocarbons; and

in response to the residual value being greater than the threshold, repeating the combining and deblending operation to determine an updated residual value.

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3. The method of claim 1, comprising:

generating a deblended output via the combining and deblending operation; and

filtering the deblended output to remove a portion of the deblended output that is before the time of the seismic source excitation or before a predicted earliest arrival

15 time of a seismic wave travelling from a source location to a receiver location.

4. The method of claim 3, comprising

selecting a coherency constraint for the seismic source;

applying the coherency constraint during the combining and deblending

20 operation to the at least a portion of a seismic source survey; and

producing the receiver gather based at least in part on an output generated from the applying of the coherency constraint.

5. The method of claim 3, wherein the filtering of the deblended output is configured to be performed using a combination of hardware filtering circuitry and software filtering operations.
- 5 6. The method of claim 3, comprising filtering the deblended output to remove all portions of the deblended output corresponding to a duration of time between an indicated time and the time of the seismic source excitation.
7. The method of claim 3, comprising:
10 determining an iteration count; and
in response to the iteration count being less than a threshold:
repeating the combing and deblending operation to determine an
updated residual value; and
incrementing the iteration count.
- 15 8. The method of claim 3, comprising:
modifying the receiver gather via the combing and deblending operation to cause a migration of noise from a first portion of the receiver gather disposed after the time of the seismic source excitation toward a second portion of the receiver gather
20 disposed before the time of the seismic source excitation.
9. The method of claim 3, comprising:
initializing the deblended output to zero; and
modifying the deblended output over one or more iterations of the combing
25 and deblending operation to a non-zero value.

10. The method of claim 3, comprising:

recovering the leaked or misallocated signals generated during deblending iterations via a series of coherence-based separation, blending and combing operations.

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11. A tangible, non-transitory, machine-readable media, comprising instructions configured to cause a processor to:

determine a residual associated with input seismic data received from a seismic source, wherein the residual is indicative of a difference between expected
10 input seismic data and the input seismic data, and wherein the input seismic data is configured to be combed with an expanded window such that the expanded window comprises data generated by an earlier seismic source excitation and received before a time of a seismic source excitation that generated an input seismic trace corresponding to the input seismic data;

15 determine a deblended output based at least in part on the residual;

update the deblended output based at least in part on a result from performing one or more recovery operations configured to recover coherent signals from non-coherent signals of the deblended output, wherein the coherent signals comprise a matching parameter;

20 filter the deblended output to remove a portion of the deblended output that is before the time of the seismic source excitation or before a predicted earliest arrival time of a seismic wave travelling from the seismic source to a receiver, to generate an improved deblended output comprising less noise than the deblended output; and

transmit the filtered deblended output for use in generating a seismic image, wherein the seismic image represents hydrocarbons in a subsurface region of Earth or subsurface drilling hazards.

5 12. The tangible, non-transitory, machine-readable media of claim 11, comprising instructions configured to cause, as part of the one or more recovery operations, the processor to:

perform a separation operation on the deblended output to generate a first subset of signals associated with the coherent signals of the deblended output and a
10 second subset of signals associated with the non-coherent signals of the deblended output;

recover a third subset of signals from the second subset of signals, wherein the third subset of signals comprises the coherent signals of the non-coherent signals of the deblended output, wherein the coherent signals are signals misallocated at least in
15 part on the separation operations that generate the first subset and the second subset of signals; and

update the deblended output based at least in part on the third subset of signals resulting from performing the one or more recovery operations.

20 13. The tangible, non-transitory, machine-readable media of claim 12, comprising instructions configured to cause, as part of the one or more recovery operations, the processor to:

perform blending and combing operations on the second subset of signals to generate combed receiver gather data;

subtract the second subset of signals from the combed receiver gather data
where coherent signals are leaked into the second subset of signals to generate
subtracted receiver gather data; and

after the blending and combing and any subtraction operations, perform an
5 additional separation operation on the combed receiver gather data or the subtracted
receiver gather data to generate the third subset of signals and a fourth subset of
signals, wherein the third subset of signals comprises recovered coherent signals, and
wherein the fourth subset of signals comprises non-coherent signals.

10 14. The tangible, non-transitory, machine-readable media of claim 12,
comprising instructions configured to cause, as part of updating the deblended output,
the processor to:

generate a primary signal estimate based at least in part on the third subset of
signals, the second subset of signals and the first subset of signals;

15 compute the expected input seismic data at least in part by blending the
primary signal estimate before blending based on a time of seismic source excitations
to generate the signals;

generate the residual based at least in part on a difference between the
expected input seismic data and original input data;

20 perform deblending operations on the residual; and

update the deblended output based on the primary signal estimate and results
from the deblending operations.

15 15. The tangible, non-transitory, machine-readable media of claim 14,
25 comprising instructions configured to cause the processor to:

additively combine the third subset of signals, the second subset of signals, and the first subset of signals, and the results from the deblending operations on the residual to generate the primary signal estimate.

5 16. The tangible, non-transitory, machine-readable media of claim 11, wherein the deblended output comprises one or more previously misplaced signals that have been captured and recombined with initially identified coherent signals associated with a primary signal estimate.

10 17. The tangible, non-transitory, machine-readable media of claim 11, comprising instructions configured to cause the processor to:
perform the one or more recovery operations after determining the deblended output.

15 18. The tangible, non-transitory, machine-readable media of claim 11, comprising instructions configured to cause, as part of the one or more recovery operations, the processor to:

separate the deblended output into the coherent signals and non-coherent signals;
20 separate the non-coherent signals into additional coherent signals and additional non-coherent signals;
combine the additional coherent signals, and the coherent signals or previously deblended output to update a value of the residual; and

update the deblended output based at least in part on the coherent signals or the previously deblended output, the additional coherent signals, and the updated value of the residual.

- 5 19. A device, comprising:
a first processor configured to:
- determine a residual associated with input seismic data received from a seismic source, wherein the residual is indicative of a difference between expected input seismic data and the input seismic data, wherein the input seismic data is configured to be combed with expanded windows such that the expanded windows comprise data generated by an earlier seismic source excitation and received before a time of a seismic source excitation that generated an input seismic trace corresponding to the input seismic data;
- 10 update a value of the residual based at least in part on a separation operation that separates coherent signals from noise signals in an output associated with the residual determined to be remaining energy for separation or a sum of the residual and a primary signal estimate;
- 15 extract non-coherent or weak-coherent energy from the coherent signals;
- 20 in response to satisfying an end condition, determine a deblended output comprising the coherent signals;
- filter the deblended output to remove a portion of the deblended output that is before the time of the seismic source excitation or before a predicted earliest arrival time of a seismic wave travelling from the seismic source to a

receiver, to generate a filtered deblended output comprising less noise than the deblended output; and

transmit the filtered deblended output for use in generating a seismic image, wherein the seismic image represents hydrocarbons in a subsurface region of Earth or subsurface drilling hazards.

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20. The device of claim 19, wherein the first processor is configured to: extract additional coherent signals from the non-coherent or weak-coherent energy; and

10 in response to satisfying an end condition, determine a deblended output comprising the additional coherent signals.

21. The device of claim 20, wherein the first processor, as part of the generating of the additional coherent signals with correct timing, is configured to: perform an iterative process that comprises updating, at each iteration, the additional coherent signals to include any further additionally recovered coherent signals.

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