

CLAIMS

1. A computer-implemented method for automated noise removal from seismic data, the method comprising:

5 receiving a seismic data set comprising a plurality of traces obtained from seismic measurements;

computing noise metrics for the seismic data set using a set of time and depth windows;

10 scanning the seismic data set to determine a first set of groups, wherein each group in the first set comprises at least a first minimum number of neighboring traces for which at least one of the noise metrics is outside a predefined specification; and

applying noise attenuation to the traces in the first set of groups;

computing the noise metrics for each noise-attenuated trace in the first set of groups;

15 scanning the noise-attenuated traces in the first set of groups to determine a second set of groups, wherein each group in the second set comprises a grouping of at least a second minimum number of neighboring noise-attenuated traces for which at least one of the noise metrics is outside the predefined specification; and

20 applying a further noise-reducing process to the noise-attenuated traces in the second set of groups.

2. The computer-implemented method of claim 1, wherein the seismic data set is obtained from a three-dimensional seismic survey.

25 3. The computer-implemented method of claim 1, wherein the neighboring traces are neighbors to each other in terms of time or depth.

4. The computer-implemented method of claim 1, wherein the noise metrics comprise coherent and incoherent noise metrics.

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5. The computer-implemented method of claim 4, wherein the coherent and incoherent noise metrics are relative to a signal strength.

6. The computer-implemented method of claim 4, wherein an autocorrelation function is used to compute the coherent noise metric.

7. The computer-implemented method of claim 4, wherein a multiple coherence function is used to compute the incoherent noise metric.

8. A computer-implemented method for automated noise removal from seismic data, the method comprising:

receiving a seismic data set comprising a plurality of traces obtained from seismic measurements;

computing noise metrics for the seismic data set using a set of time and depth windows, wherein the noise metrics comprise coherent and incoherent noise metrics, and wherein the noise attenuation for the coherent noise in a trace comprises surface related multiple elimination;

scanning the seismic data set to determine a first set of groups, wherein each group in the first set comprises at least a first minimum number of neighboring traces for which at least one of the noise metrics is outside a predefined specification; and

applying noise attenuation to the traces in the first set of groups.

9. A computer-implemented method for automated noise removal from seismic data, the method comprising:

receiving a seismic data set comprising a plurality of traces obtained from seismic measurements;

computing noise metrics for the seismic data set using a set of time and depth windows, wherein the noise metrics comprise coherent and incoherent noise metrics, and wherein the noise attenuation for the incoherent noise in a trace comprises predicted deconvolution; and

scanning the seismic data set to determine a first set of groups, wherein each group in the first set comprises at least a first minimum number of neighboring traces for which at least one of the noise metrics is outside a predefined specification.

5 10. The computer-implemented method of claim 9, wherein the predicted deconvolution comprises separation of a predicted factor of the trace based on a neighboring trace from an unpredicted factor of the trace relating to the incoherent noise.

10 11. The computer-implemented method of claim 1, wherein the first minimum and the second minimum are a same number.

12. The computer-implemented method of claim 1, wherein the further noise-reducing process comprises:

15 applying a second noise-attenuation procedure N times with N parameter sets to generate N trials of further noise-attenuated traces for each group of the second set; and selecting a trial of further noise-attenuated traces for each group of the second set.

20 13. The computer-implemented method of claim 12, wherein the further noise-reducing process further comprises:

 applying, to each group in the second set, the second noise-attenuation procedure with the parameter set of the selected trial for the group; and outputting a resultant noise-reduced seismic data set.

25 14. The computer-implemented method of claim 12, wherein the noise-reduction process further comprises:

 applying the second noise-attenuation procedure M times to the seismic data set as a whole, each time with a parameter set of a different selected trial, so as to create M candidate data sets, where M is a number of groups in the second set; selecting one of the M candidate data sets; and

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outputting the selected candidate data.

15. An apparatus for acquiring seismic data and performing automated noise removal from the seismic data, the apparatus comprising:

- 5 a seismic data acquisition system for acquiring a seismic data set, the seismic data acquisition system comprising one or more seismic sources generating acoustic waves and a plurality of seismic receivers detecting the generated acoustic waves;
- a data storage system configured to store computer-readable code and data,
- a processor configured to execute the computer-readable code so as to modify
- 10 the data,
- computer-readable code configured to calculate noise metrics based on the detected acoustic waves using a set of time and depth windows for the seismic data set comprising a plurality of traces;
- computer-readable code configured to determine a first set of groups, wherein
- 15 each group in the first set comprises at least a minimum number of neighboring traces for which at least one of the noise metrics is outside a predefined specification; and
- computer-readable code configured to apply noise attenuation to the traces in the first set of groups;
- computer-readable code configured to compute the noise metrics for each noise-
- 20 attenuated trace in the first set of groups;
- computer-readable code configured to scan the noise-attenuated traces in the first set of groups to determine a second set of groups, wherein each group in the second set comprises a grouping of at least the minimum number of neighboring noise-attenuated traces for which at least one of the noise metrics is outside the predefined
- 25 specification; and
- computer-readable code configured to apply a further noise-reducing process to the noise-attenuated traces in the second set of groups.

16. The apparatus of claim 15, further comprising:

computer-readable code configured to apply a second noise-attenuation procedure N times with N parameter sets to generate N trials of further noise-attenuated traces for each group of the second set;

5 computer-readable code configured to select a trial of further noise-attenuated traces for each group of the second set;

computer-readable code configured to apply, to each group of the second set, the second noise-attenuation procedure with the parameter set of the selected trial for the group; and

10 computer-readable code configured to output a resultant noise-reduced seismic data set.

17. The apparatus of claim 15, further comprising:

15 computer-readable code configured to apply the second noise-attenuation procedure M times to the seismic data set as a whole, each time with a parameter set of a different selected trial, so as to create M candidate data sets, where M is a number of groups in the second set;

computer-readable code configured to select one of the M candidate data sets; and

20 computer-readable code configured to output the selected candidate data.

18. At least one tangible computer-readable storage medium with executable code stored thereon which, when executed by one or more processors, performs steps comprising:

25 controlling a seismic data acquisition system for acquiring a seismic data set, the seismic data acquisition system comprising one or more seismic sources generating acoustic waves and a plurality of seismic receivers detecting the generated acoustic waves;

receiving the seismic data set comprising a plurality of traces;

30 computing noise metrics based on the detected acoustic waves for the seismic data set using a set of time and depth windows, wherein the noise metrics comprise

coherent and incoherent noise metrics, and wherein the noise attenuation for the coherent noise in a trace comprises surface related multiple elimination;

scanning the seismic data set to determine a first set of groups, wherein each group in the first set comprises at least a first minimum number of neighboring traces
5 for which at least one of the noise metrics is outside a predefined specification; and
applying noise attenuation to the traces in the first set of groups.

19. A method for seismic data acquisition and quality control processing of seismic data comprising:

10 controlling a seismic data acquisition system for acquiring a seismic data set, the seismic data acquisition system comprising one or more seismic sources generating acoustic waves and a plurality of seismic receivers detecting the generated acoustic waves;

receiving a seismic data set processed to a specified stage;

15 calculating a metric based on a detected acoustic wave for the seismic data set;
determining if the seismic data set is acceptable;

determining an aspect of the seismic data set to be corrected, correcting the aspect, and looping back to calculating the metric if the seismic data set is determined to be unacceptable; and

20 confirming a processing integrity of the seismic data set as processed to the specified stage if the seismic data set is determined to be acceptable.