MULTICHANNEL SEISMIC EXPERIMENT WITH A DRILL-BIT SOURCE

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By
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ABSTRACT

The challenge in experiments using the drill bit as a seismic source is to separate the weak drill-bit signal from noise generated by industrial activity near the well. In a new seismic experiment, the ambient elastic field is recorded during the drilling of a well with a multichannel array laid on the Earth's surface. The novel concept is the dense sampling of the acoustic wavefield in *space*, such that multichannel filtering could subsequently focus and amplify the weak signal while suppressing noise. Focusing of the drill-bit signal is possible because the drill-bit source acts as a vertical point force, and therefore the spatial coherency (moveout) of the drill-bit signal is predictable when the depth of the well and RMS seismic velocities are known.

Observations of field data recorded with a conventional 1-D seismic line during drilling show that the strongest-amplitude events in the data are noise. I apply median smoothing and iterative velocity filtering to attenuate noise whose moveout differs significantly from the moveout expected from the drill-bit signal. After velocity filtering, the drill-bit signal remains still weaker than events in the data with similar moveout across the 1-D seismic line — background noise, which has a uniform velocity spectrum, or strong noise from a source located at the surface. However, temporal cross-correlation of the velocity-filtered data with a reference signal from a geophone located in a shallow borehole, separates the signal and noise waveforms in *time*. Then, stacking velocity analysis of the cross-correlated data reveals a coherent event whose traveltime delays are consistent with those expected from the drill-bit signal.

From the analysis of these data, I obtained average traveltime delays through the subsurface, as well as models for the ambient noise. Such traveltime delays, if determined over a range of depths, could be used for time-to-depth conversion of surface seismic data

or for tomographic reconstruction of velocities near the borehole. The strong sources of noise observed in this first experiment suggest a 2-D acquisition geometry for future experiments, so that more ambitious goals, such as imaging of reflectors, could be pursued.

I expect that the processing sequence developed for the analysis of these data will be of interest also in other seismic experiments that deal with similar signal processing issues: detection of weak sources in strong noise, estimation of traveltime delays for non-impulsive signals, and accurate and efficient velocity filtering by linear transform methods.

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Table of Contents

Abstract iii

Acknowledgments v

1 INTRODUCTION 1

1.1 The drill bit as a downhole seismic source 1

1.2 Experiments using the drill-bit signal 2

1.2.1 A single-channel experiment 2

1.2.2 A two-channel experiment 3

1.2.3 A multichannel experiment 5

1.3 Methodology of the investigation 6

1.4 Thesis overview 7

2 ROBUST SIGNAL AND NOISE SEPARATION 9

2.1 Introduction 9

2.2 Examples of data 10

2.3 Attenuation of spatially uncorrelated noise by median smoothing 12

2.3.1 Overview 12

2.3.2 Weighted-median filters: review of definition and properties 14

2.3.3 Median smoothing of drill-bit data 16

2.4 Attenuation of coherent noise 19

2.4.1 Overview 19
2.4.2 Velocity filtering 20
2.4.3 Attenuation of coherent noise by linear prediction 22
2.4.4 Signal-to-noise ratios 29
2.5 Tests for the attenuation of coherent noise 32

3 DETECTION OF DRILL-BIT SIGNAL 37

3.1 Introduction 37
3.1.1 Definition of a velocity transform 39
3.1.2 Measures of moveout: different views of the velocity cube 40
3.1.3 Suppression of a strong source of noise by velocity filtering 44
3.2 Signal enhancement by cross-correlation 47
3.2.1 Introduction 47
3.2.2 Model of the cross-correlated seismograms 47
3.2.3 Average cross-correlations 49
3.2.4 Examples of noise attenuation by cross-correlation 50
3.2.5 Velocity analysis of cross-correlated data 52
3.3 Summary of results and recommendations for future experiments 55

A Some properties of tricone drill-bit sources 59

B Acquisition geometry for the OGS experiment 63

B.1 Introduction 63
B.2 Surface seismic array 63
B.3 Other measurements 70

C Least-squares inverses for time-invariant transforms 73

C.1 Introduction 73

C.2 Linear time-invariant transform pairs 74
C.2.1 Definitions of transforms in the time domain 74
C.2.2 Slant-stack transforms in the $x-\omega$ and $p-\omega$ domains 76
C.2.3 Two forms of the least-squares inverse 77
C.2.4 Finite-aperture versus infinite-aperture inverse 80
C.2.5 Inverse transform in the presence of noise 80
C.3 Toeplitz structure of the matrix of normal equations 81
C.3.1 Toeplitz structure 81
C.3.2 Properties resulting from the Toeplitz structure 82
C.3.3 Stability of the inverse, sampling, and resolution 85
C.3.4 Aliasing 87

D Stacking in terms of the data-covariance matrix **89**

Bibliography **91**

List of Tables

B.1 Parameters of the surface array in the OGS experiment 66

B.2 Parameters from the drilling logs 71

B.3 Stacking velocities from a surface seismic survey 71

List of Figures

1.1 Concept of the seismic experiment performed while drilling 2

2.1 Examples of noise and presumed signal in the drill-bit data. 11

2.2 Synthetic data: hyperbolas in spatially coherent noise. 12

2.3 Windows of data illustrating varying noise patterns 13

2.4 Running median filter applied to a sinc function 15

2.5 Median smoothing applied to synthetic data 18

2.6 Raw data displayed in *t-x*, *f-x* and *f-k* domains 19

2.7 Median-smoothed data displayed in *t-x*, *f-x* and *f-k* domains 20

2.8 Windows of data after median smoothing. 21

2.9 Windows of data after velocity filtering: noise only 23

2.10 Windows of data after velocity filtering: drill-bit signal and noise. 24

2.11 Results from linear prediction along the time axis 26

2.12 Results from linear prediction along the offset axis 28

2.13 Windows of data after the processing 30

2.14 Results of signal and noise separation applied to synthetic data 31

2.15 Results of signal and noise separation for different signal-to-noise ratios . . 32

2.16 Signal estimated from spatially uncorrelated data. 33

2.17 Comparison of spectra before and after signal and noise separation 35

2.18 Test of coherent noise attenuation for a large volume of data 36

3.1 Schematic illustration of sources at different locations in space that have the same traveltime delays across a 1-D of vertical-component geophones . 38

3.2 Coordinates of the velocity transform for non-impulsive sources 40

3.3 Hyperbolas overlaid on the data: indication of a surface source. 41

3.4 Depth-velocity spectrum computed from a 10 min long sequence of data . . 43

3.5 Depth-velocity spectrum computed from a 1 s long window of data 44

3.6 Velocity-"zero-offset time" spectra for two intervals of borehole depths . . . 45

3.7 Depth-velocity spectrum computed from 1 s of data after suppression of the surface source 46

3.8 Depth-velocity spectrum computed from 10 min of data after suppression of the surface source 46

3.9 Attenuation of coherent noise by cross-correlation 51

3.10 Detection of drill-bit signal: picking of traveltimes 54

3.11 Time-velocity spectra from surface array data cross-correlated with geophones at different depths levels 56

3.12 Average power as function of the depth of the drill bit 57

A.1 Picture of tricone drill bits 60

A.2 Sketch of a drill rig and of a drill assembly 60

A.3 Sketch of the movement of the drill bit and the corresponding source model 61

B.1 Data collected in the OGS experiment 64

B.2 Amplitude responses to monochromatic plane waves of group and channel arrays 68

B.3 Depth-velocity ambiguity for a linear array 69

C.1 Impulse responses of the operators for the slant-stack transform 76

C.2 Toeplitz structure of the normal equations 83

C.3 First columns of the Toeplitz matrices as a function of frequency 84

C.4 Comparison of the inverse slant-stack transforms computed with the conjugate and with the least-squares inverse operators. 88