SLIM
Seismic Laboratory for Imaging and Modeling

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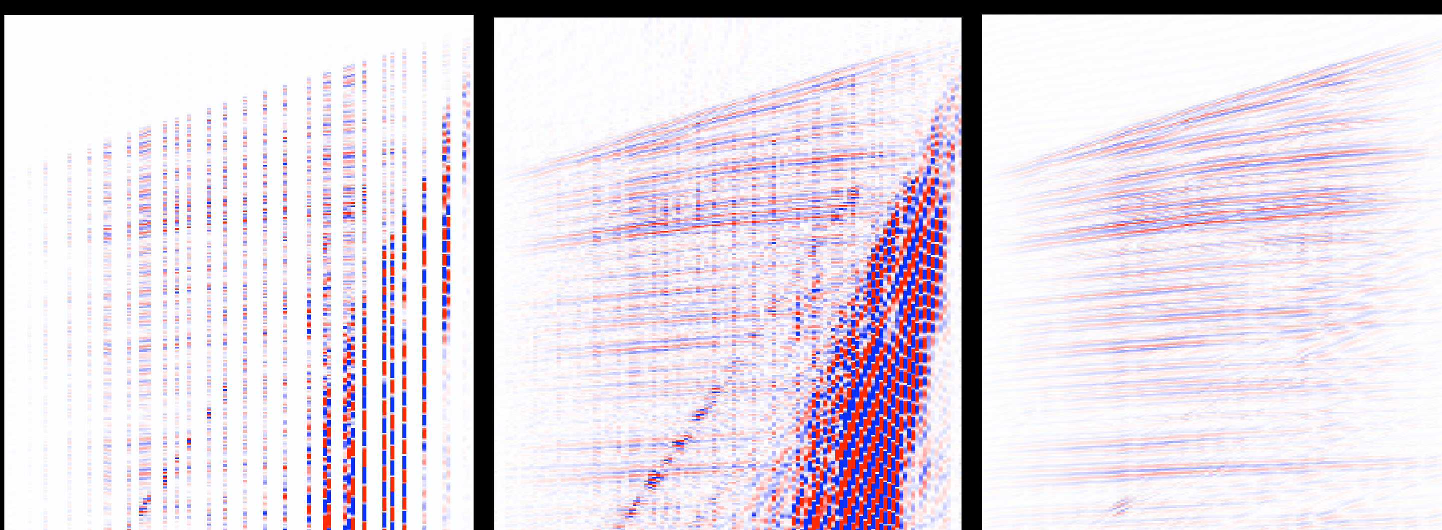
DNOISE

Dynamic Nonlinear Optimization for Imaging in Seismic Exploration

Dynamic nonlinear optimization for imaging in seismic exploration (DNOISE) is a multidisciplinary research project involving faculty members from the Mathematics, Computer Science, and Earth and Ocean Sciences departments at the University of British Columbia. DNOISE aims at one of the most pressing questions in the oil and gas industry namely ---"How to image more deeply and with more detail?" This pressing question needs to be answered if our energy-intensive society is to adequately address the current surge in demand for hydro-carbon resources.

DNOISE operates at the intersection of information, optimization and seismic theory, and aims to provide answers to the basic questions "What accuracy is attainable given a certain seismic acquisition?", and "How can we improve the acquisition to obtain a certain accuracy?" To answer these questions, DNOISE will leverage recently discovered results from information theory providing explicit conditions under which (seismic) data can be recovered from incomplete and noisy measurements.

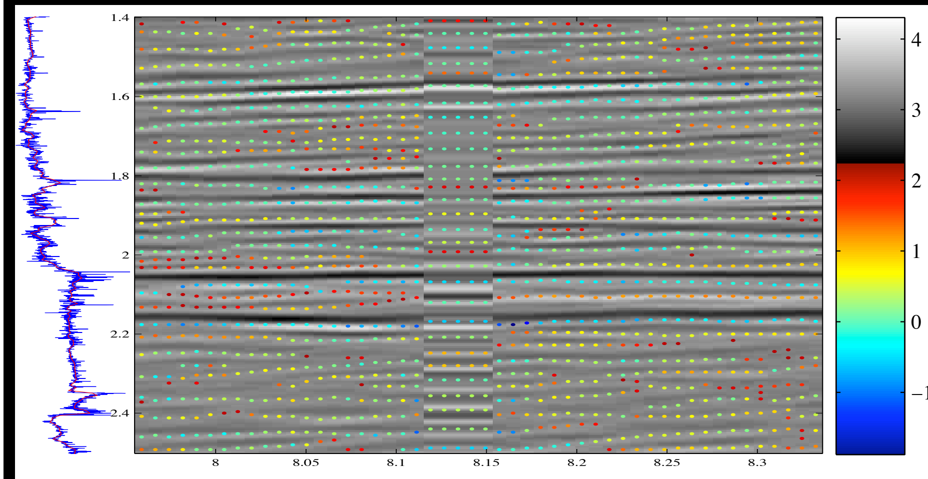
DNOISE derives its potential from the development of signal representations that are sparse and optimization techniques that promote this sparseness. This combination is exploited in DNOISE's formulation of the seismic imaging problem, leading to an improved image quality, including explicit estimates for the image accuracy.

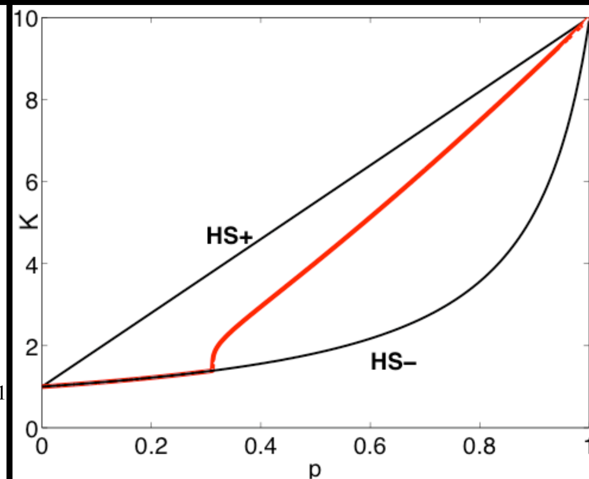


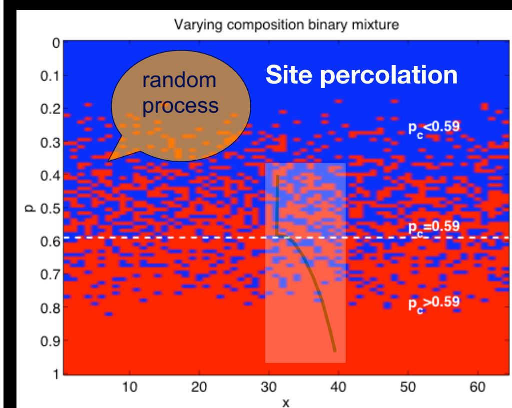
Groundroll removal result by Curvelet Reconstruction with Sparsity-promoting Inversion (CRSI) developed at the Seismic Laboratory for Seismic Imaging and Modeling (SLIM) by Gilles Hennenfent (PhD student) and Felix J. Herrmann. Left panel acquired data with missing traces. Middle panel CRSI interpolation result. Right panel result after groundroll removal by FK-filtering on the interpolated result. This research was carried out as part of DNOISE.

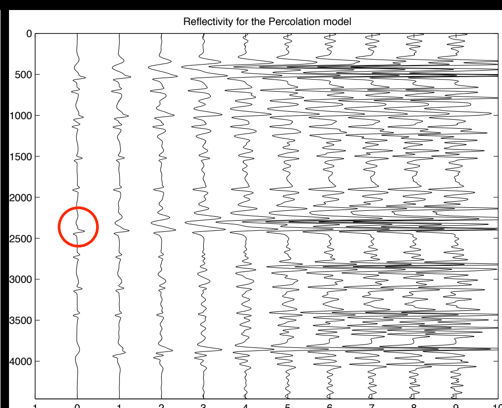
Industrial partners: BG, BP, Chevron, ExxonMobil, Shell.

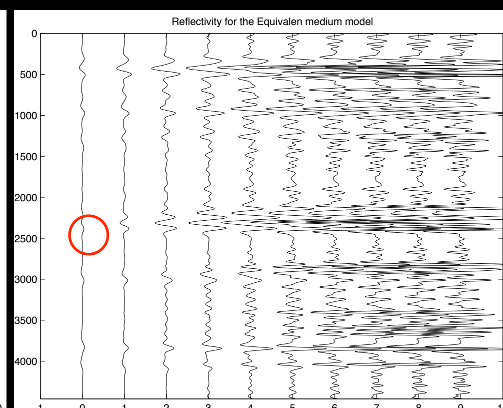
Data courtesy ExxonMobil Upstream Research Company











Seismic Characterization (top left): Fine-(blue), coarse-grained (red) well (left) and migrated data (right) with tie (middle). Compared to the reflection amplitudes the sharpness estimate not only shows a better lateral consistency across the well and hence a better well-seismic integration but also provides useful geologic information.

Percolation switch model (top right): Herrmann-Bernabé propose a percolation-based model for the elastic properties of binary mixtures. This model not only explains a sharp but continuos change in seismic velocities across the transition, but it also predicts the transition's sharpness and scale invariance. The switch model (red line) connects the upper and lower Hashin-Shtrikman(HS) bounds (black lines) for the binary mixture.

Varying composition binary mixture (bottom left): Schematic illustration of the transition by formation of strong inclusions in a weak matrix. At the critical depth (dashed line), the strong inclusions connect (percolate) and form an infinite cluster. At that point the overall strength of the rock increases sharply generating a transition.

Lithological upscaling with percolation model (bottom right): These two figures show the reflectivity derived from lithological upscaling based on the percolation theory (middle) or on the equivalent medium theory (EMT) (right). While the reflection events are preserved by the switch of the percolation model, in the EMT upscaled result the reflection events are lost.

This research was carried out as part of DNOISE.

Industrial partners: Chevron.