Achieving a Broadband Seismic Image: a 3D Dispersed Source Array Case Study

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Abstract

The industry is in pursuit of acquiring broadband seismic (low- and high- end) with the aim of improving resolution, enhanced imaging of thin beds and stratigraphic features and better velocity model building. Due to mechanical limitations of conventional seismic vibrators, they are unable to generate and emit adequate energy at the low and high end - especially the low - of the frequency spectrum. To alleviate this issue, increasing the sweep length and/or the utilization of special and custom designed sweeps have been attempted. Alternatively, dispersed source array (DSA) acquisition in which multiple narrow band seismic sources (low and hi frequency sources) are operating simultaneously and unconstrained to conduct a super high density seismic survey at a record time. In this paper, we describe the world's first 3D unconstrained, decentral-ized and dispersed source array field experiment. During this novel blended acquisition design, 24 vibrators generat-ing two different types of sweeps were employed achieving a maximum of 65,000 vibrator points during 24 hours of continuous recording, which represents significantly higher productivity than a con-ventional seismic crew operating in the same area using a non-blended centralized acquisition mode. In this experiment, the survey was divided into 12 tiles, with each tile containing two vibrators; one operating at a low-frequency mode (1.5 to 12 Hz) and the other operating at a middle- to high frequency mode 6 to 96 Hz. This "*ready and available*" configuration of continuous recording and unconstrained shooting mode produced a complex wavefield due to the severe crosstalk noise generated by adjacent sources and overlapping frequency bands. Therefore, a customized processing workflow was designed, which included a number of de-blending workflows as well as special treatment of the two different sweeps. An iterative sparse inversion in frequency-wavenumber-wavenumber (FKK) is employed as the main de-blending tool allowing us to proceed with conventional processing flow. Furthermore, a novel least-square based method is used to match and merge the two datasets originated from the low and mid-to-high frequency bandwidths. Comparisons are shown of several seismic attributes such as amplitude-vs.-offset (AVO) trends, similarity analysis as well as relative seismic impedance sections for both conventional and DSA datasets. As part of reducing the acquisition cycle time and improving seismic broadband imaging and resolution while optimizing costs, a novel acquisition survey was conducted. Acquiring ultra-high-trace density data using a decentralized and unconstrained source blended mode produces high-quality broadband seismic images in a significantly shorter acquisition time and without sacrificing data quality.