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Optimization of 3D Land Seismic Survey Design

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ABSTRACT

In recent years, advances in seismic acquisition technology, coupled with the increasing need to acquire high-quality subsurface imaging for low-relief and stratigraphic traps, led to an enormous growth in seismic channel count recording systems. This has enabled denser wavefield sampling and higher productivity vibroseis acquisition based on point sources and distance-separated simultaneous slip-sweep acquisition. Acquiring as much data as possible is often used as a simple approach to the problem of inadequate data quality. The ultimate goal of seismic survey design is to acquire a true 3D full-azimuth, long-offset, densely sampled seismic data for optimal subsurface imaging, while balancing acquisition cost, crew productivity and data quality. Nonetheless, there is no single template that can fit all surveys as the acquisition geometry is influenced heavily by not only the target depth but also the near-surface geology. Therefore, as the range of possible survey designs continues to increase with the interdependence between different geometrical, operational, cost and productivity parameters, the problem of finding the best possible survey design is very challenging. In this paper, we present an integrated framework to evaluate the designs of 3D land seismic survey geometry. In comparison to conventional survey design optimization approaches, the proposed approach takes into account not only a wide variety of geophysical parameters, but also operational and costs constraints. The approach simulates tens of thousands of possible combinations within a priori narrow ranges of simulation parameters to form the basis of the survey parameter solution-space. This is followed by a search for the best possible survey designs that minimize an objective function, while striking a balance between various constraints. The approach systematically captures from integrated productivity and cost databases, unique values of unconstrained cycle times and unit rates for each simulated geometry design. Examples of simulation parameters include the macro geometry of sources and receivers. A sensitivity analysis is conducted to analyze and assess the impact of the simulation parameters on the final optimal solution. Fold values, offset range, cost and productivity derived from the simulations are among key components of the solution space. A case study of the optimization approach is shown, and the impact on the survey design based on data-driven decision making is highlighted.