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Evolution of Land Seismic Acquisition with CSI on the North Slope

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ABSTRACT

Seismic acquisition methods in the Arctic have evolved significantly over the past decade from both a technical and operational perspective. New and enhanced techniques have allowed for the acquisition of much higher quality 3D seismic data with less operational effort, decreased HSE exposure and increased efficiency and productivity over the course of a full acquisition season. Land acquisition in an Arctic environment does not come without a spectrum of difficulties and sensitivities due to operating in a remote and climatically challenging setting. The biggest limitations of the Arctic environment are the short season length and the difficulty in accessing tundra in remote areas. Operational capability in the Arctic is generally dictated by available quantity of equipment, suitability of recording systems and crew experience. Balancing this with stringent HSE requirements, cost effective survey design and incorporating new technologies plays a significant role in the overall success of each seismic season. ConocoPhillips has used compressive sensing theory coupled with other modern acquisition concepts such as nodal technology and simultaneous sourcing, to develop a new acquisition method called Compressive Seismic Imaging (CSI). Simultaneous sourcing consists of using of several single vibrators, each transmitting a single sweep independently, rather than arrays of vibrators taking multiple sweeps at each source point. CSI allows for acquiring source points with minimal temporal and spatial separation. and afterward uses a deblending method to separate individual shot records when the data are processed. Deblending simultaneously acquired source points has been verified by several case studies designed to demonstrate that it was possible to achieve the same or better quality data than from earlier surveys using fleets of multiple vibrators. The high efficiency of simultaneous sourcing relative to historical methods allows a significant increase in both source points and trace density, and therefore a notable improvement in signal to noise ratio (S/N). Non-Uniform Optimal Sampling (NUOS) is another component of the CSI method. This implementation of compressive sensing theory has allowed for the optimization of source and receiver stations in a program, meaning a reduction in and more flexibility in the positioning of both. Source and receiver stations may be offset around obstacles such as water bodies and rugged terrain, and can be dropped in areas that pose a safety and/or environmental risk. The impact on subsurface data coverage, as a result of relocated or dropped points, is compensated for during the reconstruction stage of the processing flow. Therefore, there is less of a requirement to acquire every planned source and receiver point than has historically been the case. CSI has evolved Arctic seismic acquisition in several significant aspects. Coalescing NUOS, nodal and simultaneous source techniques, the number of source stations acquired in a 24-hour period has now increased by an order of magnitude. Concurrently, the amount of receiver stations required per spatial unit of area (I.E. mi2) has dropped. The result is higher quality data with an overall reduction in operational effort. Moving forward, this concept will allow for the acquisition of much larger 3D seismic surveys within a single season on the North Slope than previously possible.