

Optimizing Well Locations in the Niobrara

The Niobrara shale play with its rugged terrain, environmental sensitivities, structurally complex geology and fractured shale reservoir exemplifies the unique operational and imaging challenges often found in unconventional reservoirs. For one E&P operator looking to optimize the location of horizontal wells and their associated hydraulic fracturing designs, ION conducted a new wide azimuth 3D seismic survey that combined ION's expert survey design and planning, data acquisition using the FireFly® cableless recording system and VectorSeis® sensors, and data processing using GX Technology's AZIM™/OVT PreSTM technology. As a result, the client was able to quickly and efficiently locate and complete three new horizontal wells that resulted in a 5-10x increase in productivity relative to previous wells in the area.

UNCONVENTIONAL RESERVOIRS

Optimizing Well Locations in the Niobrara

Challenge: Gather data necessary to determine optimal well placement, despite narrow data acquisition time window caused by wildlife restrictions.

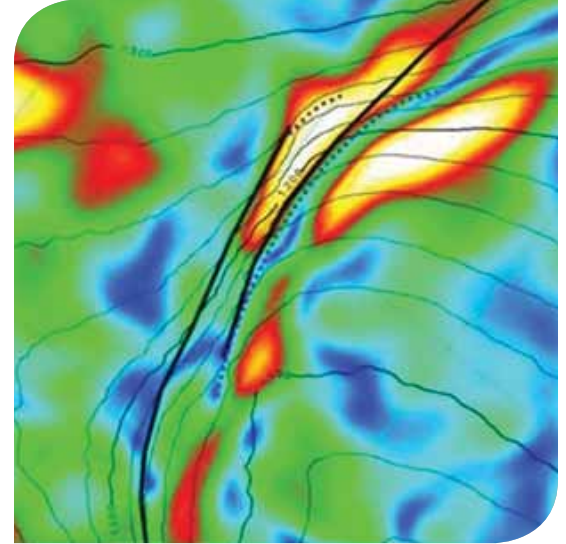
Approach: Survey design, planning, and acquisition managed by ION's GeoVentures™ group; seismic data acquisition using FireFly cableless land recording system and VectorSeis digital sensors; advanced data processing and interpretation by ION's GX Technology group.

Result: Operator improved upon comparable area well productivity by 5-10x.

IMAGING SUBTLE RESERVOIRS IN ENVIRONMENTALLY SENSITIVE AREAS

An E&P company operating in the highly variable, fractured Upper Cretaceous Niobrara Formation wanted to target their horizontal wells into zones of high natural fracture intensity that were associated with faults and fault systems. Optimal drilling locations for unconventional reservoirs are often where naturally occurring fracture networks are enhanced or readily augmented by hydraulic fracturing. No modern seismic data existed in the area, necessitating the need for a wide azimuth, spatially dense 3D survey to meet the operator's interpretation objectives.

The operator had a very narrow window in which to 'get in and get out' given restrictions imposed by both public land use regulations and private landowner interests. Seventy percent of the area was accessible only by helicopter. The operator had put its seismic acquisition program



out to bid to several contractors, and all but one 'no bid', believing the survey objectives could not be achieved with cable-based systems given the difficult terrain and brief shooting window.

OVERCOMING THE CHALLENGES WITH CABLELESS ACQUISITION AND ADVANCED DATA PROCESSING

To enable the operator to get the data they needed, while meeting the requirements of both area ranchers and the Bureau of Land Management (BLM) for speed and environmental sensitivity, ION's GeoVentures group planned and executed a new multicomponent seismic survey using an INOVA Geophysical FireFly cableless recording system with VectorSeis digital sensors. The use of the footprint-minimizing FireFly allowed the survey to be conducted safely and efficiently.

→ Access. FireFly recorded data from 11,000 receiver points and 7,300 dynamite source points within the 45-day acquisition window required by the BLM.

“This was a very challenging acquisition project in terms of the timeline, topography, and environmental sensitivity. We couldn't have completed this project without FireFly.”

– Geoscience Manager, Regional Asset Team

→ HSE performance. FireFly survey design, deployment/retrieval, and shooting operations were guided by the Connex™ command & control system, which allows for highly accurate and stakeless equipment deployment and risk-minimizing route management of field personnel.

→ Image quality. FireFly eliminates the equipment-based constraints imposed by cable-based systems, allowing surveys to be designed based on imaging objectives. In areas posing access challenges, FireFly's flexibility allows geoscientists to increase subsurface sampling density while also capturing the benefits of full-wave data recording. As a result, reservoirs can be imaged with higher resolution, and rock properties, such as natural fracturing and brittleness, can be characterized, both of which are proving critical for success in unconventional reservoirs.

Following acquisition, ION's GX Technology group was engaged to process the data and used a proprietary pre-migration workflow to preserve travel time and amplitude details. Significant geologic dip in the area prevented the use of traditional methods of accounting for azimuthal anisotropy, so the team partitioned the data into offset vector tile (OVT) bins. These vector-offset volumes were then individually

migrated to preserve the measurements needed for high-quality azimuthal velocity analysis in the presence of structure.

The interpreters used the $V_{fast} - V_{slow}$ OVT attributes to identify areas of high azimuthally varying anisotropy within the reservoir horizon. These were inferred to correlate to zones of high fracture density. As suspected, many of the anisotropic zones were located proximate to the faults cutting through the reservoir horizon. Even near the faults, however, anisotropy was quite variable both laterally and with depth.

SUCCESSFULLY OPTIMIZING WELL LOCATIONS

Based on the data, the E&P operator drilled and completed a series of three horizontal wells targeting the inferred zones of natural fracturing. Well productivity improved by 5-10x compared to offset wells in the same area.

NIOBRARASCAN LAND PROGRAM

ION's NiobraraSCAN™ was the first of ION's growing library of ResSCAN™ 3D data programs. Available for immediate licensing, this 26-square-mile, multi-client survey was acquired in 2008 using the FireFly full-wave cableless recording system, developed by ION and now offered by INOVA Geophysical.

STANDARD DELIVERABLES:

- Surface Consistent Decon (utilizing AZIM™ velocity analysis). Final Stack (no post-stack migration, whitening or spatial filtering). Final Post-Stack Migration (enhanced)
- AZIM Azimuthal Velocity Analysis (analyzed every 3x3 CDP). AZIM Velocity Volumes (RMS & internal volumes)
- Kirchhoff PSTM. Final Stack (no post-stack migration, whitening, or spatial filtering)

ADVANCED OUTPUT DISPLAYS:

- AxiDecon™ Flow (utilizing AZIM velocity analysis)
- Vector Tile PSTM (OVT) (preserved azimuth migration)
- AZIM Azimuthal Velocity Analysis (analyzed every 3x3 CDP)
- WAVO™ Wavelet-based Isotropic AVO (two-term fit; angle limited)



ABOUT ION

ION Geophysical Corporation is a leading provider of geophysical technology, services, and solutions for the global oil & gas industry. ION's offerings are designed to allow E&P operators to obtain higher resolution images of the subsurface to reduce the risk of exploration and reservoir development, and to enable seismic contractors to acquire geophysical data safely and efficiently.

To learn more about how ION helps oil & gas companies and seismic contractors solve their toughest imaging and operational challenges, visit us at iongeo.com.

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