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DeepLook-CS

Crosswell seismic imaging service

APPLICATIONS

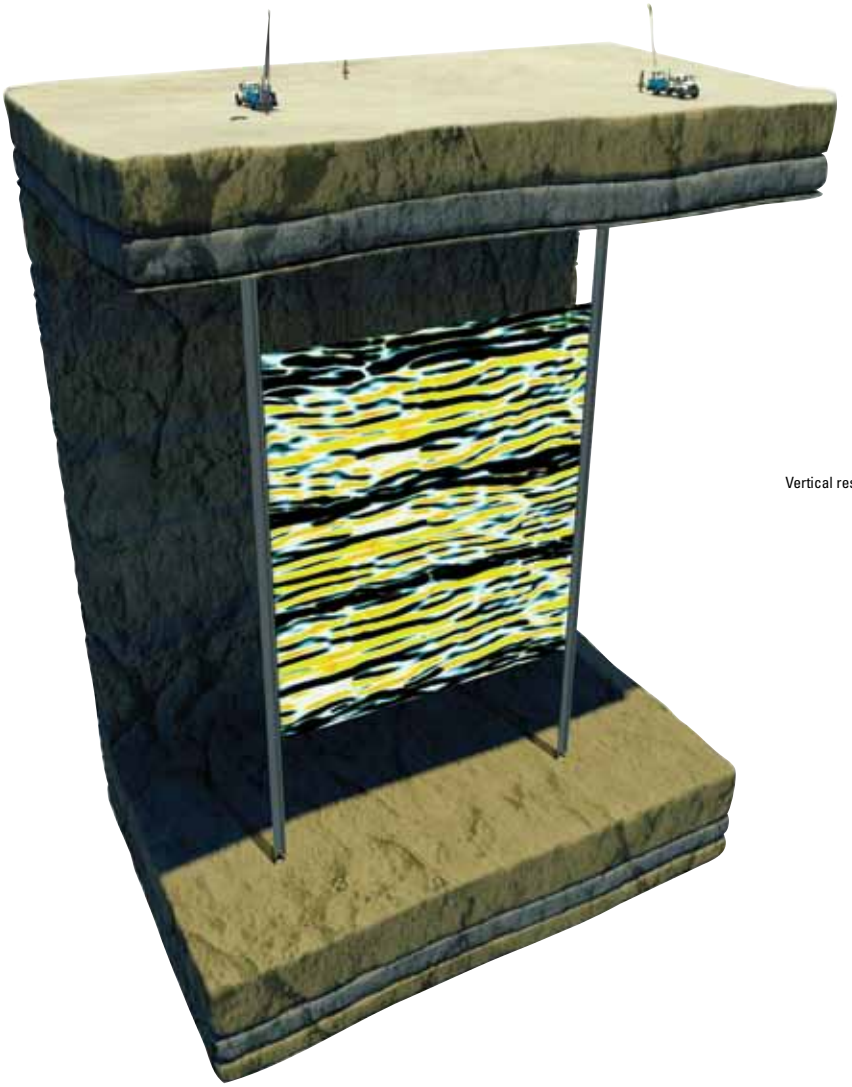
- Bypassed oil identification
- Waterflood monitoring
- Enhanced oil recovery
- Unconventional gas
- Heavy oil and thermal operations
- Reservoir characterization
- CO_2 sequestration
- Hydraulic fracture imaging and characterization

Crosswell seismic imaging of the reservoir delivers up to 100 times the resolution of surface seismic data to improve your understanding of reservoir geometry, rock properties, and fluid migration.

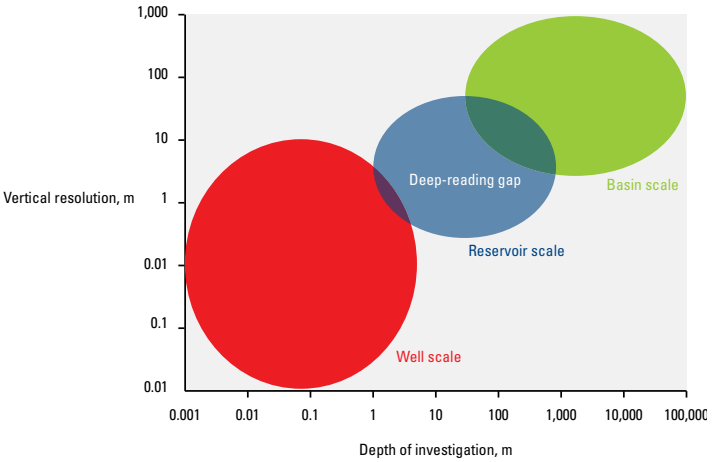
DeepLook-CS* crosswell seismic imaging bridges the resolution gap between well logs and surface seismic measurements, giving you answers at a reservoir scale. The resulting seismic imaging is up to 100 times the resolution of 3D seismic surveys, revealing subtle details of reservoir structure and significantly improving the accuracy of monitoring reservoir fluid migration.

High resolution between wells

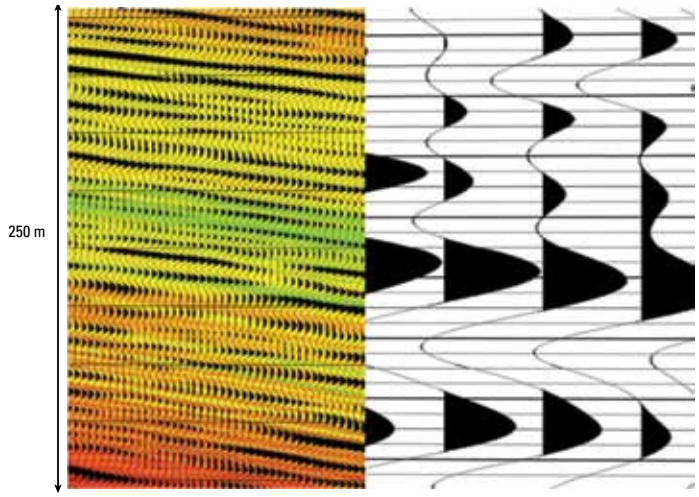
Crosswell seismic imaging operations usually involve simultaneous access of two or more wells. A downhole seismic source is lowered into one well, and a receiver array is lowered into one or more adjacent wells. As the source is moved up the wellbore it transmits very high bandwidth sound waves (100 to 2,000 Hz) through the interwell space to the receivers, where the seismic data is collected.



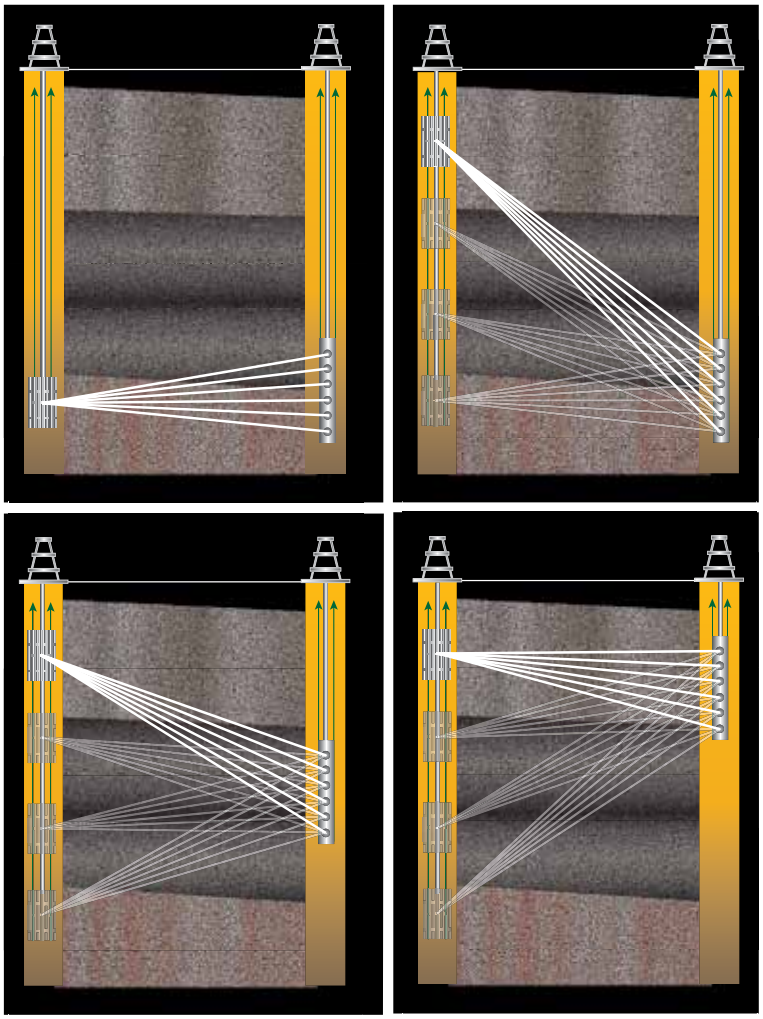
The receiver array is then repositioned in the well, and the source again transmits sound waves, with the process replicated until all areas of the reservoir or zone of interest are covered vertically. Velocity, reflection, and other sonic properties are measured to provide structural and physical characteristics in both horizontal and vertical directions.



DeepLook-CS measurements bridge the deep-reading gap.



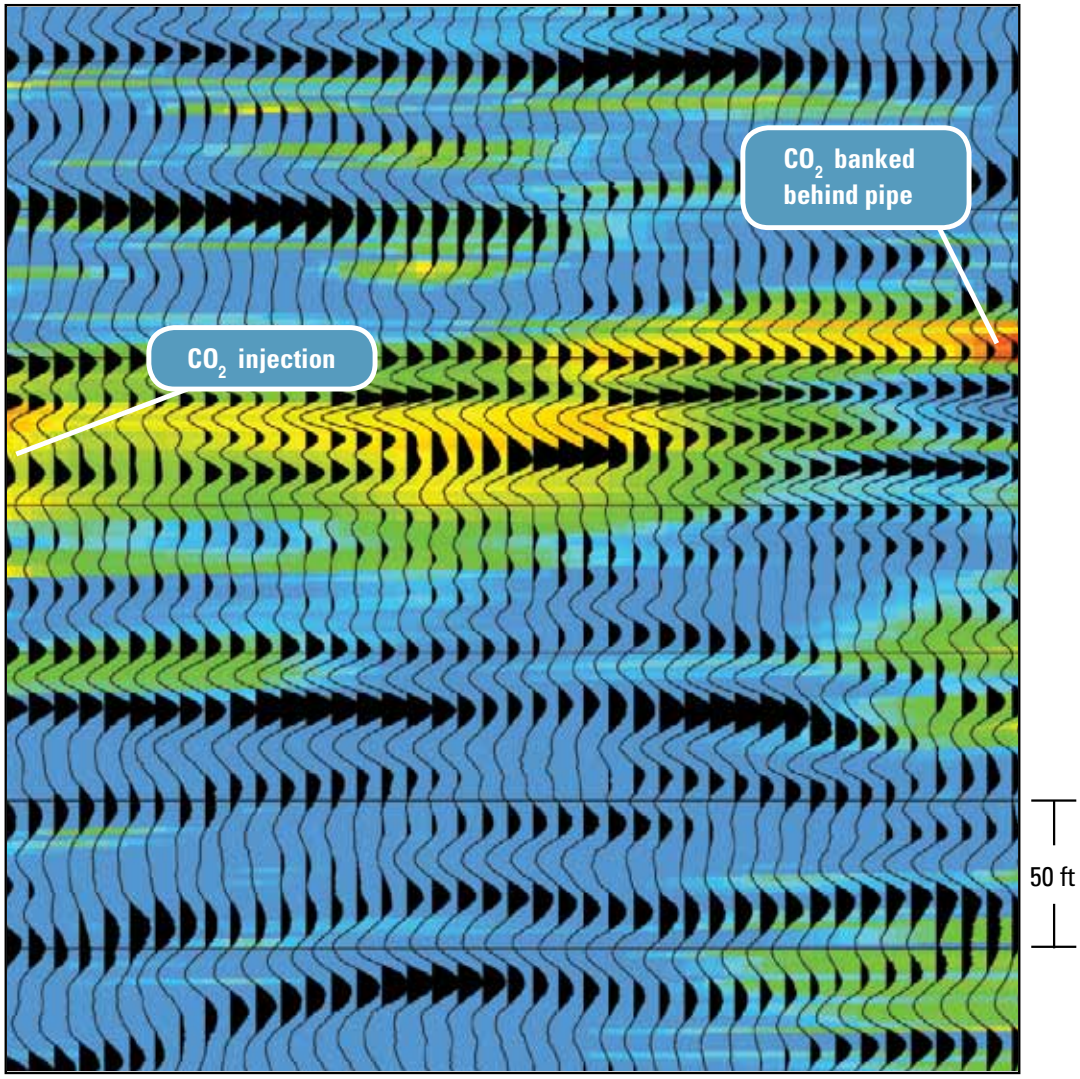
The resolution of DeepLook-CS imaging is up to 100 times that of conventional seismic surveys.



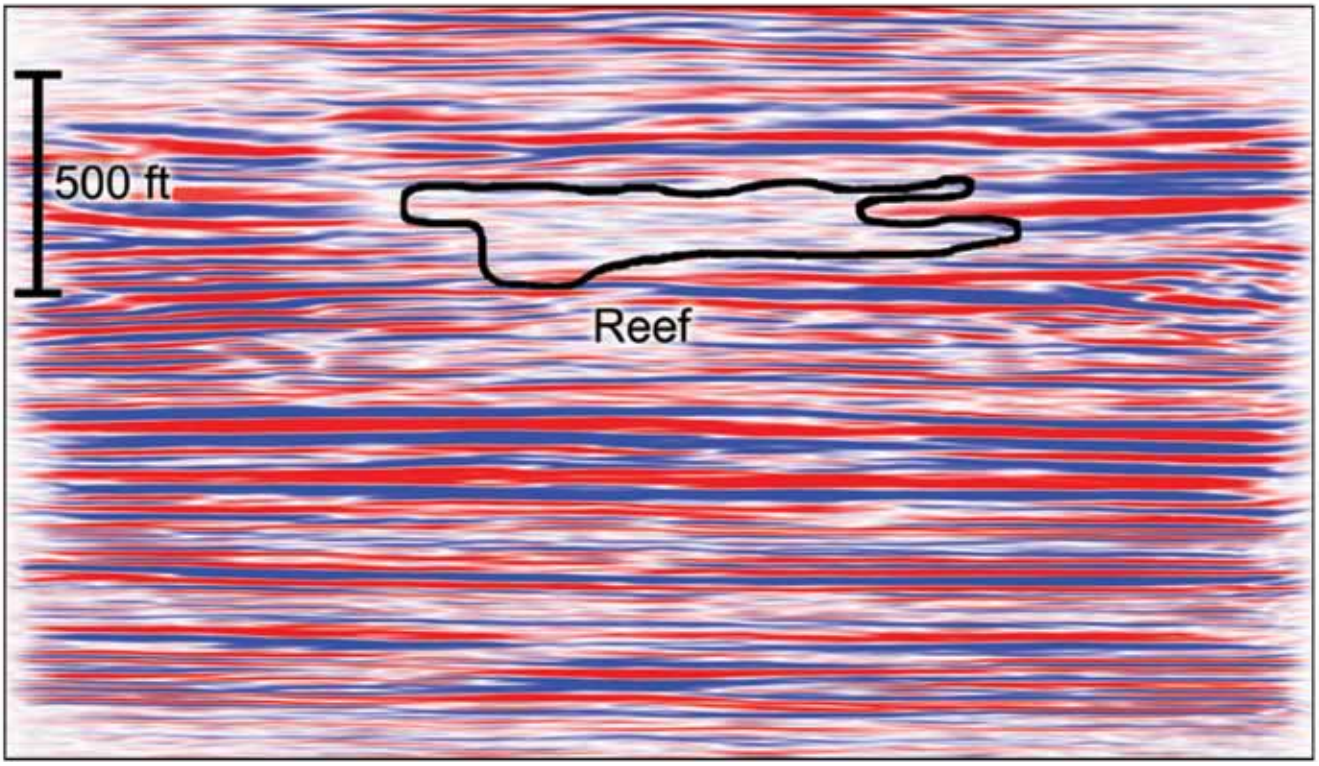
Deeplook-CS crosswell surveying employs a seismic source in one well and receivers in another well to image reservoir intervals with a vertical resolution of 5 ft [1.5 m].

Insight with accuracy

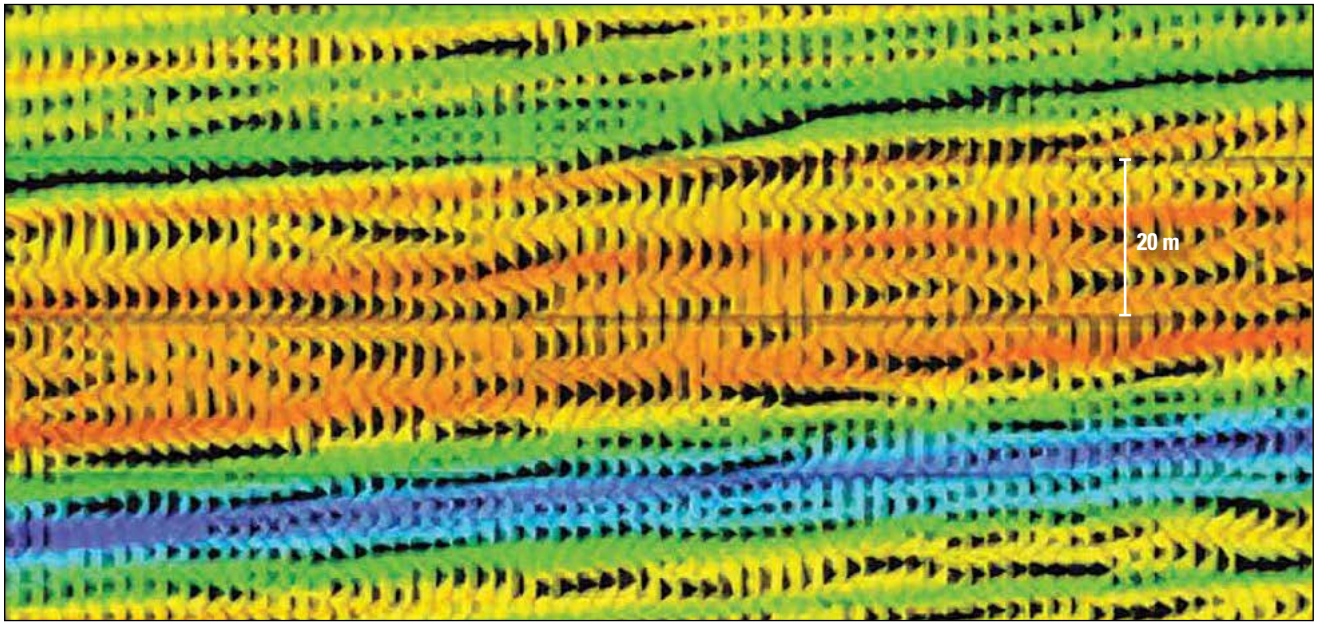
With the ability to image subtle details of reservoir structure as well as provide unprecedented accuracy in time-lapse imaging, DeepLook-CS crosswell seismic imaging is applicable for the most rigorous imaging applications. From providing critical information about reservoir structure, thickness, and continuity to the subsequent mapping of fluid behavior with velocity changes identifiable to as low as 2% in time-lapse images, DeepLook-CS images deliver the accurate answers operators need.



Conducting DeepLook-CS crosswell seismic imaging before implementing a water-, steam-, or CO_2 flood provides a high-resolution view of the structural complexity of the reservoir. This information can be used to evaluate the chance for success or enable planning of remedial action earlier in the life of the flood operation, saving time and money. In additional to improving initial understanding of the reservoir, DeepLook-CS imaging can be used to monitor the progress of enhanced oil recovery operations. In this time-lapse image, the presence of gas banking shows that the CO_2 flood is performing poorly. The 50-ft interval indicates the high resolution of the DeepLook-CS image.



The presence of a carbonate reef was revealed only through high-resolution DeepLook-CS crosswell seismic imaging—conventional surface seismic cannot identify structures at this scale.



DeepLook-CS crosswell seismic imaging provides the detailed data critical to true understanding of the reservoir. These channel sands were identified in high resolution on the crosswell image.

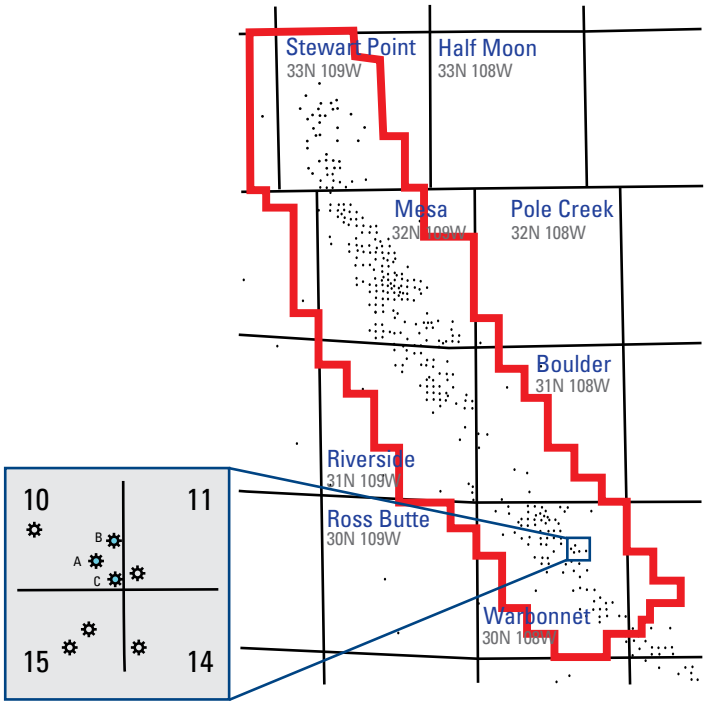
Case studies

Optimizing tight-gas infill drilling

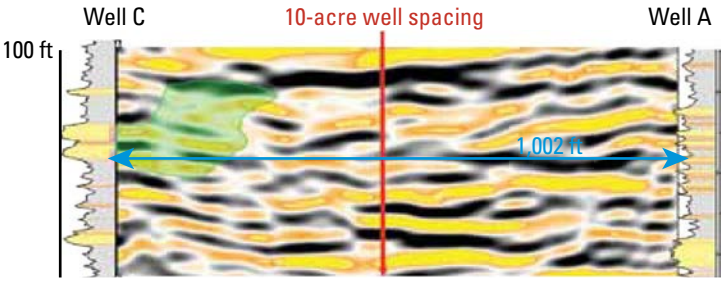
Ultra Petroleum Corporation wanted to optimize the drilling pattern for the highly discontinuous, ultratight, stacked sand bodies of the Pinedale reservoir in Wyoming,USA. However, subsurface layer attenuation and low density contrast in the highly compartmentalized sand-shale sequences obscured the sand bodies on conventional seismic surveys.

Because the DeepLook-CS seismic signal is projected directly into the reservoir, it does not travel through the highly attenuating unconsolidated near-surface layers. Thus, much higher frequencies can be achieved at the downhole receivers to deliver seismic imaging with 3- to 5-ft [0.9- to 2-m] vertical resolution. This high resolution was necessary to accurately image sand bodies because they range in height from 9 to 15 ft [3 to 5 m].

Two crosswell seismic profiles were recorded at Well A–Well B and Well A–Well C before hydraulic fracture stimulation in Well C. The DeepLook-CS surveys were performed over a 3,280-ft [1,000-m] interval in the wells, which are 1,002 ft [305 m] apart. The reservoir heterogeneity of the imaged sand bodies was then superimposed with fracture wing images from HRM* hydraulic fracturing monitoring of each of the 20 stages of the hydraulic fracture stimulation job to determine the bounds of the induced fracture within the reservoir. From the superimposed images, an optimal infill drilling spacing of 10 acres was identified. Compared with the previous 40-acre drilling pattern, the recover factor improved to 58.8% from 17.5%.



DeepLook-CS crosswell seismic profiles were obtained at Well A–Well B and Well A–Well C in south Pinedale field.

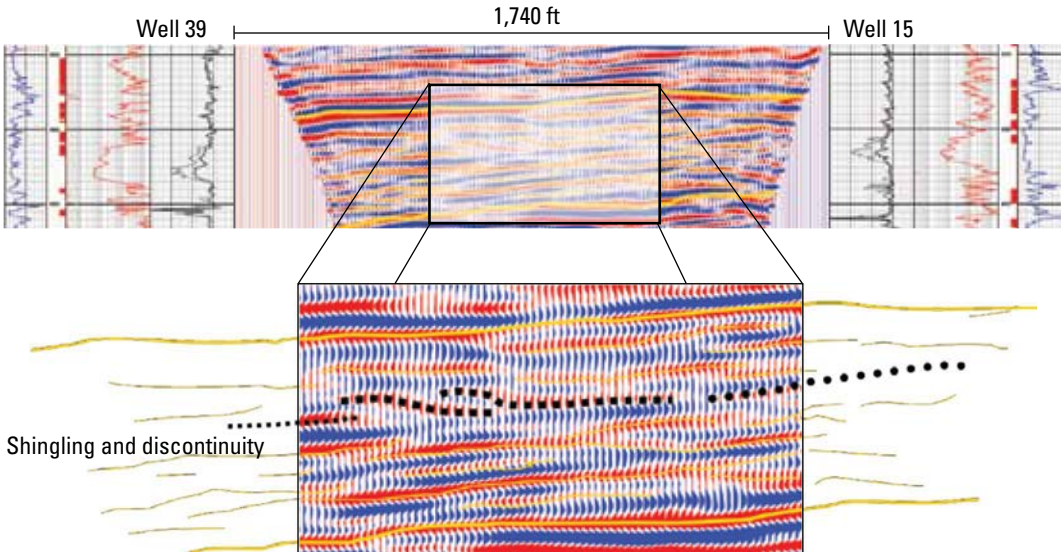


The composite of the superimposed HRM image on the high-resolution DeepLook-CS image clearly identifies the dimensions of both the reservoir sand body and the hydraulic fracture wing extension (green).

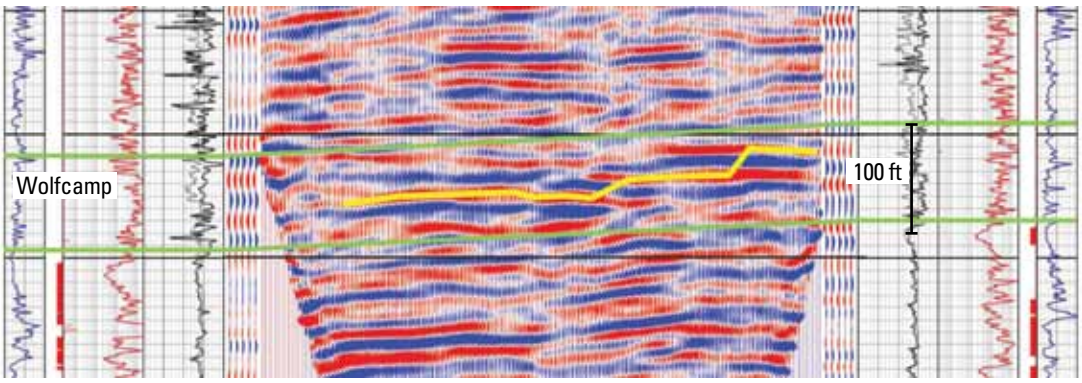
Identifying reefal porous zones to improve production 300%

Chevron needed to identify discontinuous porosity zones in the Wolfcamp formation in Vacuum field, New Mexico, USA, that average only 10 to 15 ft [3 to 5 m] thick, which is below the resolution of 3D seismic surveys. An additional concern was that vertical wells drilled into the peaks of isolated structural highs thought to be algal mounds were poor producers in Vacuum field.

Four DeepLook-CS seismic profiles were acquired to further characterize the structure of the mounds. The interpreted section confirms the highly discontinuous, complex nature of the reservoir, explaining that the low production results from incomplete drainage occurring with vertical well placement. The high-resolution seismic images were used to revise the reservoir model to account for the amount of compartmentalization observed and include specific structures. With this accurate model, a new horizontal drilling strategy was launched, with the wells intersecting porosity zones between clinoform structures identified in the images. The strategy is successful, with production from a single horizontal well more than 300% greater than that from one of the vertical wells.

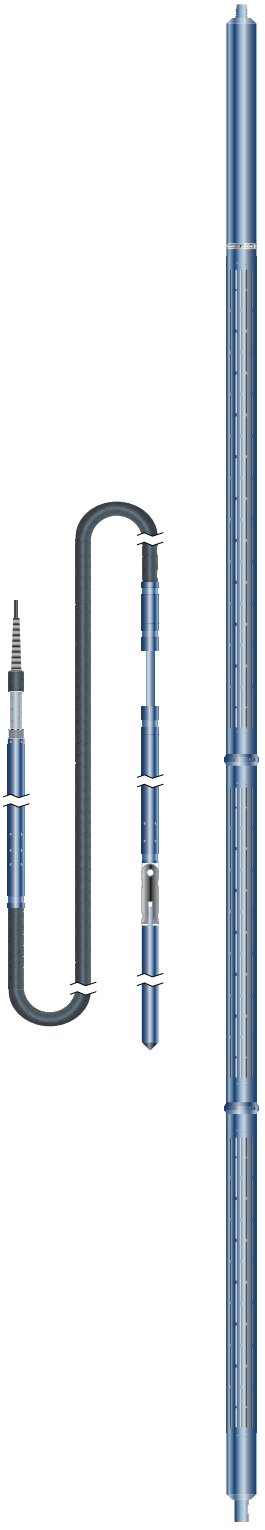


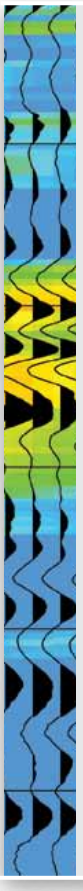
Discontinuous clinoform features are identifiable in the interpreted crosswell seismic data from the Vacuum field Wolfcamp survey.



Horizontal well placement (yellow) was specifically designed to intersect Wolfcamp porosity zones between the clinoforms.

DeepLook-CS





DeepLook-CS Interwell Distance†		
Source Well	**Receiver Well**	**Well Spacing, ft [m]**
Cased hole	Cased hole	100–3,280 [30–1,000]
Open hole	Open hole	100–3,280 [30–1,000]

† Depends on noise, completion, and formation attenuation characteristics.

Specifications		
	DeepLook-CS Piezoelectric Source	**DeepLook-CS Hydrophone Receiver Array**
Temperature rating, degF [degC]	302 [150]	350 [177]
Pressure rating, psi [MPa]	10,000 [69]	10,000 [69]
Well size—min., in [cm]		
Open hole	4.5 [11.5]	2.25 [5.7]
Cased hole	4.5 [11.5]	2.25 [5.7]
Well size—max., in [cm]		
Open hole	No limit	No limit
Cased hole	No limit	No limit
Outside diameter, in [cm]	3.5 [8.9]	1.6875 [4.2]
Length, ft [m]	17.2 [5.24]	Twenty levels,† 5-ft spacing: 118 [36] Twenty levels,† 10-ft spacing: 218 [66.4]
Mud type or weight limitations	No fluid restrictions	No fluid restrictions
Frequency range, Hz	100–2,000	100–4,000

† Eight hydrophones per level

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