In the northeastern part of the U.S., oil and gas development has impacted water resources, creating a need for new exploration techniques. Seismic reflection surveys have been repurposed for groundwater exploration. These surveys are able to map fine-scale stratigraphic details at depths of up to several thousand feet. Advanced processing techniques allow the separation of sand from shale and the creation of maps indicating net sand thickness, percent shale content, and other stratigraphic features. The data can also be processed to display attributes of the reflected wavelets, providing information on the properties of the rock and fluids within the unit. Attributes such as amplitude, similarity, and coherency are used to distinguish sand from shale and produce maps of net sand thickness, percent shale content, and other stratigraphic information.

The cost of drilling for groundwater development to depths ranging from 2,000 to 5,000 feet limits the amount of test drilling that can be conducted. The limited availability of data makes developing these resources risky and expensive. Further, the aquifer properties of many formations vary significantly over short distances based on stratigraphic changes in the aquifer. It is difficult to predict the potential yield of an aquifer at a given location without additional information.

The target zones for drilling are often deeper than the ones usually developed in aquifers for drinking water or irrigation wells. These zones are also beyond the depth of exploration for many surface groundwater geophysical methods. In addition, aquifers with brackish or saline water contain permeable sand zones, faults, and other stratigraphic and structural features that control well yield. The latest evolution is the rise of three-dimensional (3D) data acquisition, dramatically improving the resolution of the seismic method even in structurally complex areas.

Seismic reflection surveys have become a routine first step when exploring new oil and gas plays or for planning ways to increase the recovery in historic producing fields. Historically, the relatively high cost to acquire and process high resolution seismic reflection data has limited the routine use of this method for water supply applications. However, recently the cost of processing and interpreting reflection data has decreased to the point where it is a viable technology for water exploration.

Oil and gas production requires water, often in areas that have limited resources or where water use by energy companies is contentious. Though oil and gas production provides a higher return than many conventional uses, water has or will become a limiting factor in many oil fields. The scarcity of water in many areas has increased interest in sources of “unconventional” water (fresh to brackish water sources at depths of 2,000 to 5,000 feet). Though usually more expensive, these aquifers are often less controversial to develop. In many cases it is the only water that is readily available because it has not been tapped by other users and is isolated from the shallower water sources which may be fully allocated. These sources are particularly attractive in states that allow land owners to develop deep isolated aquifers separately from the allocation system of shallow aquifers and surface water.

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confined aquifer at depths of 450 to 2,000 feet. A standard groundwater exploration survey was conducted using an electrical resistivity survey to map sand units in the upper 500 feet. The two data sets were combined to produce depth slices showing the location of permeable sand channels at various depths across the site (Figure 1).

The data was used to direct a drilling program that consisted of four wells at depths ranging from 250 and 800 feet below ground surface that exceeded the targeted capacity of 400 acre feet per year (af/yr) from a confined aquifer. Figure 2 presents the correlation of the amplitude anomalies (red and orange horizontal lines) that indicate the presence of sand units with the resistivity log of a 800 foot deep test hole (peaks indicate shale layers). The results demonstrate that the seismic amplitude predicted the presence of sand layers nearly perfectly below a depth of approximately 450 feet. The data indicates that additional aquifer units are present between depths of 1,000 and 1,750 feet (see figure2). The resistivity data predicted the location of permeable sand deposits in the upper 400 feet. Similar results are also possible to obtain for exploration targets to much greater depths.

As oil and gas development continues conflicts over water sources will only increase. Employing existing seismic reflection data to explore for deeper groundwater sources provides a viable tool to find unused sources of water that can be utilized for production needs without competing with adjacent land owners for traditional sources of water. This option will reduce project delays and reduce overall production costs by avoiding conflict. More importantly seismic reflection can provide certainty for one of the key resources necessary for efficient and economical oil field production.

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