ARI Technology Background

Acoustic Reservoir Imaging, LLC

Abstract

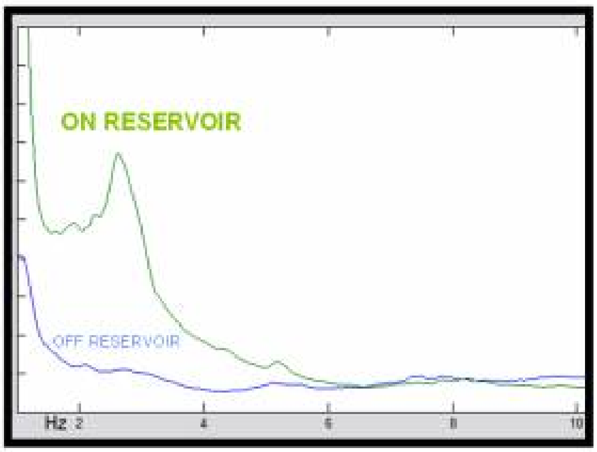
By passively measuring the long-wavelength, low-hertz eigenfrequencies of the earth, Acoustic Reservoir Imaging (ARI) complements the various active seismic exploration technologies to accurately determine the locations and sizes of subter-ranean hydrocarbon reservoirs. ARI extends and enhances the capabilities of ex-isting infrasonic methodologies through the application of unique data collection and analysis practices which have resulted in 75% success rates in locating viable deposits of hydrocarbons. In research since 1995 and in commercial use since 2003, the technology behind ARI has helped drillers and investors improve their successes, while avoiding dry holes. In addition, the noninvasive nature of ARI makes it suitable for wide-spread application in fragile eco-systems and palatable to environmentally-sensitive landowners.

Introduction

Active reflective seismic exploration technologies provide data used to map the structure of the earth, including those types of formations frequently associated with hydrocarbon deposits. While these exploration methods have been useful in discovering large reservoirs, they have also been subject to error and they typically involve the use of heavy equipment, vibrators and explo-sions, all of which can cause extensive damage to the area being explored.

Passive seismic exploration measures the naturally occurring low-frequency seismic signals which constantly occur within the earth. Generated by the movements of the oceans, microseis-mic movements within the earth and other natural activities, these sounds are well below the fre-quencies audible by human ears, but are measurable by sensitive seismometers operating within the range of .01 to 6 hertz.

Military applications of infrasonic technology have been used for decades to locate subma-rines. Research into monitoring low frequency signals for hydrocarbon exploration began in the middle of the 1990s. As a peculiarity, when the infrasonic energies from natural seismic sources pass through a hydrocarbon field, the amplitude of the sound waves increase enough to stand out significantly from the background seismic signals. This anomaly has occurred within passive seismic surveys conducted at thousands of points located in Texas, Oklahoma, Kansas and Ala-bama by Acoustic Reservoir Imaging, LLC.



Real Data Example — Alabama

While the cause of the amplitude increase in infrasonic signals passing through a hydrocar-bon deposit is subject to research and discussion, one theory suggests the hydrocarbon fields re-duce the frequencies of higher-frequency signals, adding them to the amplitude of the existing infrasonic signals. Whatever the cause, the increase in signal amplitude appears to be unique to infrasonic energy passing through hydrocarbon deposits and the junctures of these deposits with water. Hydrocarbon fields of larger thickness cause greater increases in signal amplitude.

Survey Methodology

Passive ARI surveys employ no heavy equipment and require no artificially generated en-ergy, relying instead on the eigenfrequencies of the earth. Field equipment consists of several seismometers, telemetry cables and a data recorder mounted on an all terrain vehicle.

ARI Methodology Flow Chart

Seismometers. Because the API systems measure amplitude differentials, the surveys use vertical axis seismometers. While research is assessing the potential value of triaxial sensors for amplitude surveys, single-axis sensors appear to provide all of the data needed for accurate detection.

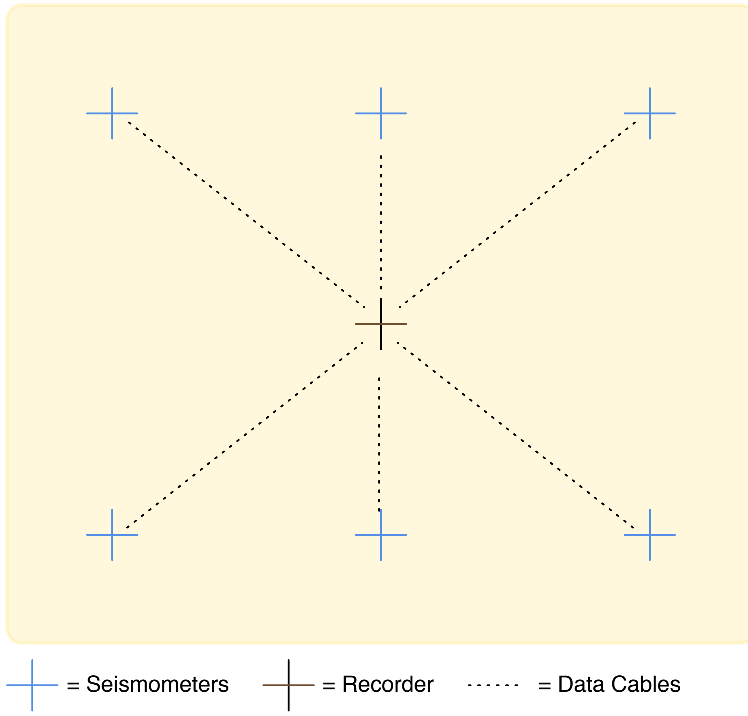
Seismometer Coordinates. In an active survey using artificially induced signals, the data for sensors is associated by time and the physical location of each sensor. In a passive survey, the data for each seismometer is independent, but the map coordinates of each sensor is important for determining the size and shape of any hydrocarbon deposits.

Before going to the field, the location of each seismometer to be used in the survey is mapped by longitude and latitude, then programmed into a GPS. The sensors are laid out in an array, considering distance between sensors and topographic conditions.

The field operator sets the sensors at the specified coordinates, then runs power and data cables to the centrally located data recorder.

Current practices records data for one to six seismometers simultaneously. When additional recording points are needed, the seismometers are moved to other locations and recorded. This is possible because time coordination of the data is not important.

In the future, ARI surveys will use dozens of sensors to enable the mapping of larger areas at one time.



Sensor And Recorder Setup

Noise Reduction. As with any seismic survey, useful signals must be separated from background noise. To help attenuate noise during recording, the seismometers are buried slightly below the surface. This reduces noise generated by wind and changes in ambient temperature, for example.

Recording. The raw analog data from the seismometers are digitized and recorded. Recording duration varies from 1000 to 3000 seconds. The recording duration depends on the amount of background noise—such as truck traffic or grazing livestock—with longer durations needed when noise levels are higher.

Analysis. An ARI survey can accurately determine the boundaries and thickness of a hydrocarbon reservoir.

The raw data from the recorder are converted to mathematical and statistical sets specific to the interpretation of hydrocarbon indicators.

The data are filtered for noise, then anomalies are identified within a frequency range of 2 to 4 hertz.

Events having a cross-correlation coefficient outside these thresholds are rejected.

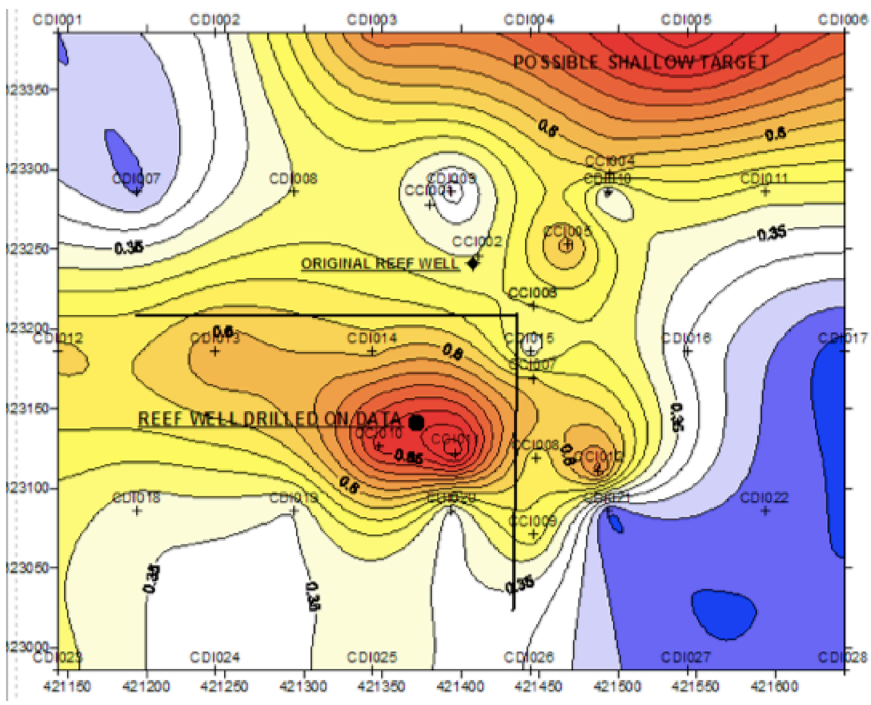
A comparison of relative amplitudes are then calculated. Individual high amplitudes relative to the geographical being surveyed are identified and located on a map.

Results. While it has been demonstrated in patents by Gendelman and Chutov that low frequency spectral anomalies frequently exists above hydrocarbon reservoirs, using their suggested methods on more than 2500 data points has shown that not all areas with anomalies do, indeed, contain hydrocarbons.

While employing some of the methods of Gendelman and Chutov, the collection and analysis methods used by ARI highlights ratios relative to the highest and lowest amplitudes to pinpoint geographical areas with high productivity potential. The results have been 75% accu-rate.

Case Studies

Palo Pinto Reef Prospect—Jones County, Texas. A regional 3D seismic survey had identified a small Palo Pinto Pinnacle Reef. Because of an adverse land owner situation, the previous operator had elected to drill a Palo Pinto Reef test at an alternate location (ORIGINAL REEF WELL) that was slightly off the crest of the structure. The well potential tested 111 BOPD flowing. However, the well watered out after producing only 3000 BO. It was believed that the premature abandonment was the result of producing the well at high flow rates (in excess of 100 BOPD) and coning water. The prospect concept was to redrill the reef at the optimum structural location and restrict the producing rate to approximately 35 BOPD, thereby maximizing ultimate recovery.

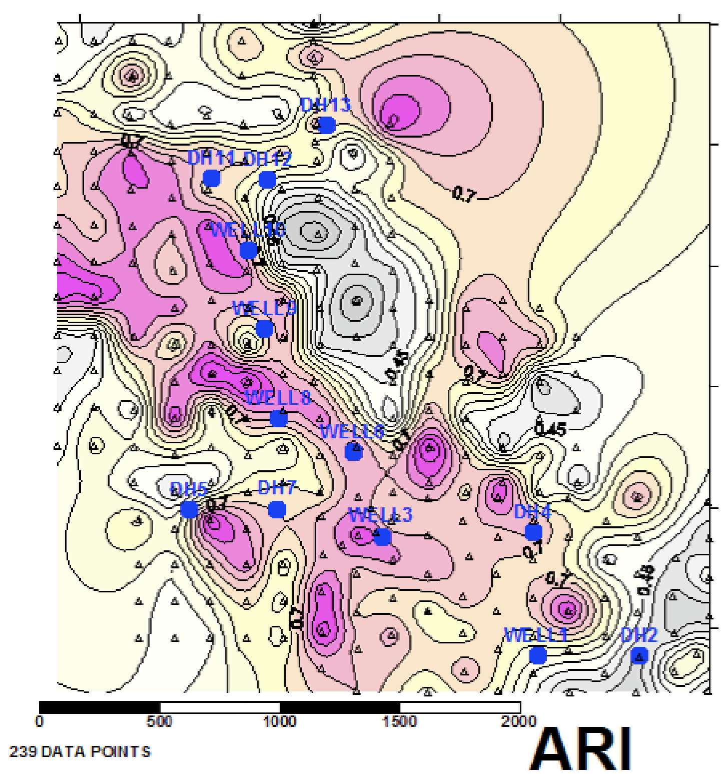


Jones County, Texas

In 2004 ARI conducted a close spaced (330’) survey of the prospect area. The survey (map above) indicated a small hydrocarbon accumulation surrounding the crest of the structure that included a maximum of 10 productive acres. Based on the survey results ARI recommended that the well not be drilled. Another operator drilled the well in mid

2005. In 18 months it has accu-mulated 2855 BO and is currently pumping 2.5 BOPD. The survey also identified another hydro-carbon anomaly on the Northern edge of the prospect area. That anomaly is off the Palo Pinto structure as identified by 3-D seismic and is interpreted as coming from the shallow Cook Sd which also produces in the area. That idea has yet to be drilled.

West Texas Development Drilling. Over the past 3 years several contiguous ARI surveys have been conducted to assist in the selection of development well locations in a recently discovered West Texas multipay area. Several years prior to the initial survey a dry hole had been drilled in the southeastern portion of the prospect (DH2). A new field discovery well had been drilled west of the original dry hole (Well 1) and at the time of the first ARI survey had produced in excess of 50,000 BO. The survey map represents approximately 640 acres and includes only a portion of this continuing project. In this portion of the survey 5 successful development wells and 5 dry holes have now been drilled. The dry holes were drilled based on other land and geological data and the results are consistent with those predicted by ARI. Please note the evidence of depletion surrounding Well No. 2 as evidenced by the reduced relative amplitude of the recorded signals mapped in the vicinity of that location.



West Texas Channel Sand

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