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Horizontal drilling and multi-stage hydraulic fracturing form the indispensable duo that's driving shale gas plays across North America. That innovative revolution has transformed a sunset industry into a thriving sector that's apparently capable of supplying the continental gas market for the next century. But as the technology spreads, operators have found what works in one play doesn't necessarily translate to the next. Each geological prospect has to be "solved" before large-scale commercial production can be a success.

An important tool for helping operators crack new plays quickly has been derived from technology used to monitor earthquakes and geothermal activity. Houston-based MicroSeismic, Inc. (MSI) has developed the capability to monitor hydrological fracturing of gas-bearing shales. From the surface or near-surface, an operator can monitor and interpret the tiny vibrations triggered when tonnes of frac fluids and proppants are pumped at high pressure into reservoirs some 5,000 to 15,000 feet underground.

The technology creates high-definition imagery that indicates the direction and penetration of the fracs, with results reportedly superior to the more costly method of drilling adjacent monitoring wells to reservoir depth. Further, MSI's product performs that task in real time. Operators can adjust and tweak the fracing procedure as it advances stage by stage down the length of the horizontal wellbore. In addition, future horizontal wells and frac stages can be more effectively placed across a shale gas play.

The technology is being used not only to help solve new shale plays, but to optimize production within plays. "The variability of the shales from well to well is driving more and more operators to monitor 30 to 40 per cent of their wells, and in some plays 100 per cent," says Canadian-born Peter Duncan, MSI's founder and president. "It is a matter of value proposition. As the unit price comes down, operators are able to employ the monitoring on more and more wells. At some price point it will make sense to do it on every well."

MSI uses either its FracStar surface-based data acquisition or its Buried Array permanent network of geophones (guaranteed for at least 10 years), buried from 100 to 500 feet underground - to avoid near-surface noise - to gather very low-level acoustic energy emissions. The process relies on the small seismic events, or micro-earthquakes, created at depth by the frac procedure. There's no need for an active source of vibration, such as dynamite or vibroseis vehicles. Fracing data is wirelessly communicated to MSI's Passive Seismic Emission Tomography (PSET) system for interpretation. Signal attenuation by the overburden makes conventional seismological earthquake location techniques ineffective. In contrast, PSET allows MSI to use the dense array of geophones to "beam steer" or sum the output of the entire array to detect and locate microseismic activity deep below.

The technology has been taken up by some of the continent's biggest producers, Duncan says. It's now in use in tight gas plays from the Marcellus and Haynesville in the United States to British Columbia's Montney and Horn River Basin, along with the Bakken tight oil play in

Saskatchewan. Duncan, a geophysicist who founded MSI in 2003, describes himself as "more like the midwife than the inventor" in this case. A Colorado University professor developed earlier versions for hydrothermal exploration in Russia. MSI, purchasing the tech-nology, advanced and adapted it for oil and gas applications.

"What it has become is a tool for putting large-aperture arrays over entire oilfields, turning them on and listening to all the production activity in the oilfield, whether it's frac monitoring or injection of fluids or production of fluids, in order to hear those sensitive sounds, pinpoint their location and their nature, and really allow the reservoir engineer to know something about the dynamics of what is going on in his oilfield," Duncan says.

Encana Corporation, an early user, tested the surface-based FracStar in 2007 and installed the first permanent Buried Array in 2008. Both systems were applied at its Haynesville shale gas play in northern Louisiana. The Calgary-headquartered producer went on to install another three permanent Buried Arrays in the Haynesville.

MSI has now installed about 20 Buried Arrays, almost all to monitor frac operations. But the rapidly growing company also sees potential in monitoring everything from steam injection in the oilsands to carbon sequestration and enhanced geothermal systems. "We have only begun to scratch the surface," Duncan says.

Peter Duncan teaches a high-tech trick or two to Texas

Like many people who move "temporarily" to a new city, the Canadian president of MicroSeismic, Inc. (MSI) migrated to Houston in 1986 "on a three-year stint, and I am still here." Peter Duncan, who earned his PhD in geophysics from the University of Toronto, began his career as an exploration geophysicist with Shell Canada in Calgary.

After moving to Houston with Digicon Geophysical Corp., Duncan helped start ExploiTech Inc. After that firm was taken over, the New Brunswick native co-founded 3DX Technologies Inc. in 1992 and MSI a year later. He also served as president of the Society of Exploration Geophysicists in 2003-04.

Early-stage funding was not a problem for MSI. But "when we came into the market with this surface array technique for doing hydrofrac monitoring, the established service providers using the legacy earthquake detection technique pushed back pretty hard," Duncan recalls. "[They] said that these surface arrays can't work, and it was really just a matter that they didn't understand multi-channel seismic processing.

"They came from the earthquake location fraternity and I came from the 3-D seismic fraternity. So I understood migration and multi-channel processes like this and, for me, it was a no-brainer," the MSI founder says. "It took me probably two to three years longer to overcome that market reticence than I had predicted. But now we have won some awards for this technology, which means we have turned the corner in the marketplace."