

Trials with weights dropped from helicopters in northern Canada have led instead to a highly controllable, ground based seismic impact source vehicle that compares favorably with conventional dynamite acquisition methods.

Designed and built in late 2003, the Explorer 860 buggy has been used with high repeatability to acquire 3D and 2D seismic data since mid-January

Seismic weight drop quest leads to improved data, costs, footprint

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[Video](#) of this system in operation is available to subscribers at www.ogjonline.com. Click back issue on left navigation bar and enter issue date (Mar. 22, 2004). Subscribers who have not registered for the subscription area of OGJ Online can register by clicking the Subscribe tab at the top of the home page. Follow links for Customer Service.

2004.

The vehicle's hydraulic system generates a thump by forcing a cast steel weight against a base plate on the ground. Multiple units can be used at the same time.

The resulting seismic data have a signal to noise ratio as good as or better than conventional dynamite source records in the same area, said Mike Bahorich, Apache Corp. executive vice-president of exploration and production technology and former president of the Society of Exploration Geophysicists.

The potential for cost savings ap-

pears to be as much as 40% in areas where tree cutting is not needed and at least 15% of the total seismic acquisition budget in most areas, said Jim Ross, a geophysicist with Apache Canada.

Environmentally, the overall footprint is greatly lessened because dynamite is not used, shot holes need not be drilled, and fewer trees need be cut.

The exercise is an example of cooperation between a contractor and an oil company that may represent one of the few means of future innovation in seismic acquisition, Apache said.

Helicopter trials

Apache in late 2000 decided to explore using a helicopter weight drop system in forested, difficult-access areas (OGJ, Sept. 10, 2001, p. 76).

The challenge was to find a way to eliminate or minimize surface access while still obtaining quality seismic data.

In field tests in March 2001, a helicopter normally used for moving seismic equipment was equipped with eight hooks on which were hung various weights under the pilot's control, said Dave Monk, Apache's manager of geophysics.

"The focus on the helicopter was trying to acquire the seismic in a very environmentally friendly fashion with-

out ever having to visit the source point. You just drop the source from the helicopter and forget it."

But Apache found it difficult to manage safety levels in production areas. The falling weights, while providing accurate seismic data, could not be used in all areas because of the danger of striking pipelines or



Explorer 860 buggy, created by Apache Corp. and Polaris Explorer Ltd., Calgary, on the job for Apache in the Zama, Alta., area (Fig. 1).

other objects on the ground.

Thinking moved toward a way of creating the impact from the ground.

Evolution to Explorer

The answer was a custom designed, four-wheel buggy with a hydraulic thumper system suspended from one end (Fig. 1).

The thumper apparatus consists of a 2,600 lb. weight that can be raised as much as 24 in. above ground.

The hydraulic cylinder has a nitrogen gas charged accumulator whose pressure can be adjusted. The stroke length and downward hydraulic force exerted on the weight can be adjusted, and various force outputs can be stored in the system memory and recalled for use as needed.

Gimballing assures that the mass hits the base plate perpendicularly, and a synchronized global positioning system locates the source points precisely.

The buggy's weight holds the 54 in. diameter base plate to the ground until the shot is generated (Fig. 2).

System timing, in submicroseconds, is so accurate that multiple buggies can be used simultaneously if higher energy levels are required.

Apache estimated the maximum strike force at upwards of 650,000 lb, but precise controllability of the system minimizes ground roll and optimizes signal generation.

Polaris Explorer Ltd., Calgary, work-

Stack section shows comparison of data from weight drop (left) and dynamite (Fig. 3).

Explorer's "drop" system and 2,600 lb weight can generate a maximum force estimated at greater than 650,000 lb (Fig. 2).

ing closely with Apache's Ross and with development funding from Apache, designed and built the Explorer.

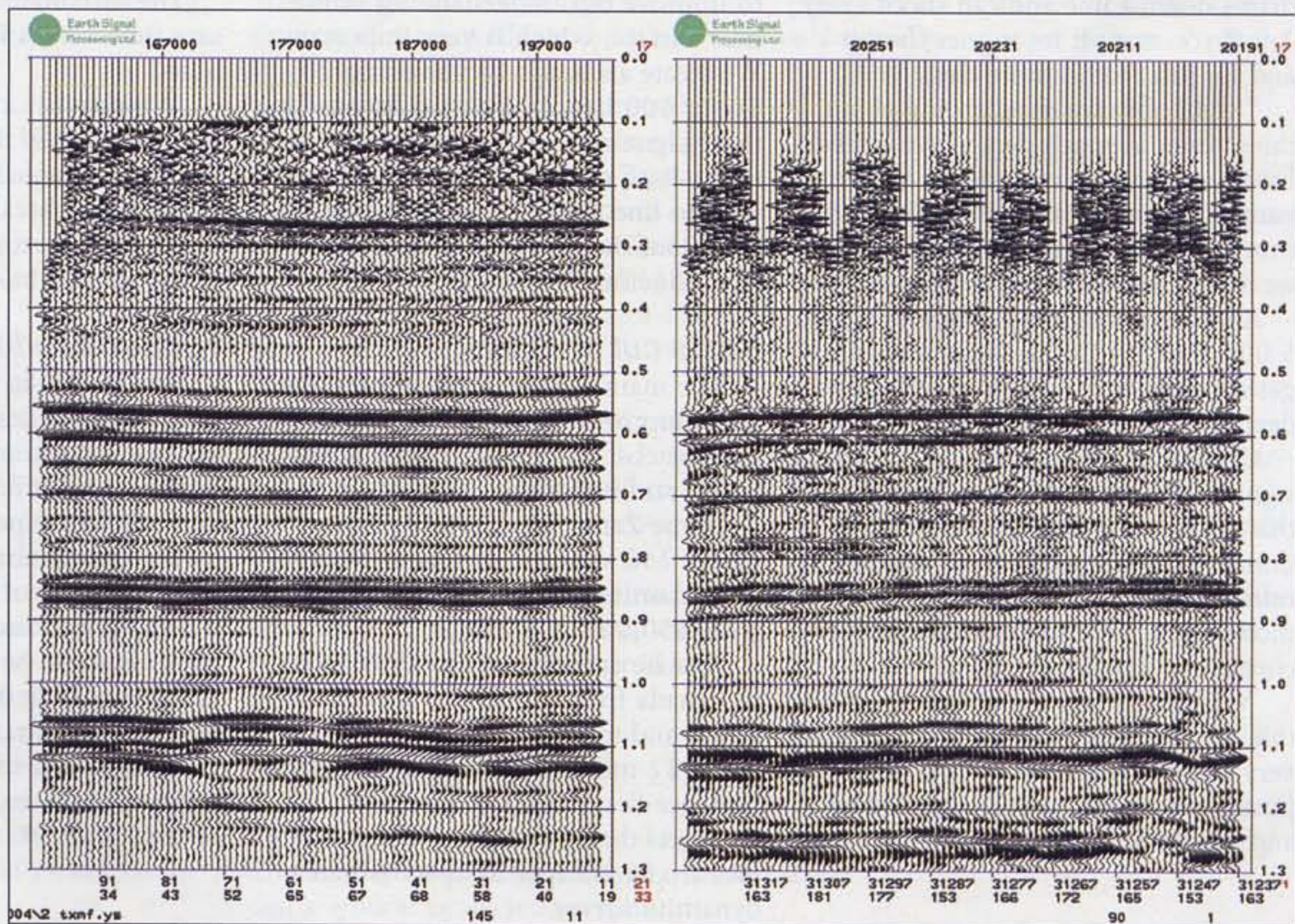
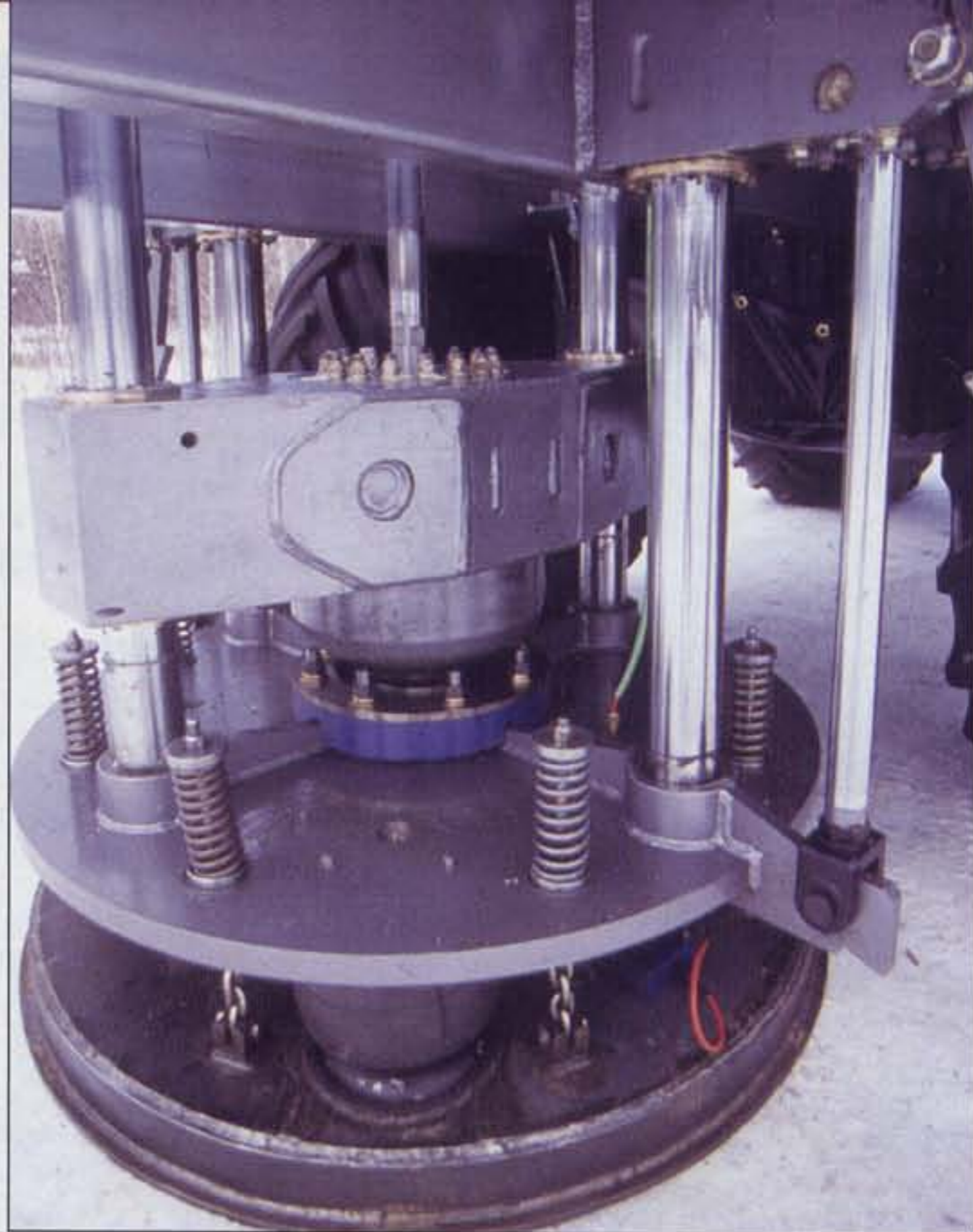
Data quality

An impact at 65% impulse, compared with one at full impulse, eliminated much of the ground roll and enhanced overall signal to noise.

Signal to noise ratios were found to be at least as good as conventional dynamite source records in the same area (Fig. 3).

"Previously we would have drilled a

fairly sparse number of dynamite holes because of the expense; here we don't have any constraints on the number of





Explorer's base plate leaves an erodable, 54-in. diameter imprint (Fig. 4).

shot points," Monk said. "The unit drives down a line and can shoot every 2 ft if you want it to; it goes thump and we just record more data.

"Right now we're recording about three times as much data as we would have done had we recorded it with dynamite, but recording three times as much data hasn't cost any more than recording data normal shot density."

Apache is imaging geology to 5,000-6,000 ft in the Zama area and getting reflection energy significantly deeper than that.

Canada, like many other places, has a significant near surface statics problem that distorts the deeper image. Traditionally this has been solved through refraction statics, or reconstruction or modeling of near surface velocities to correct for the distortion.

"One nice thing about this source is that because it is an impulse you get a very sharp first arrival energy as opposed to a vibrator which starts slow and speeds up," Monk said.

"I have no doubt that this is going to improve our understanding of the near surface, which is very important. We create an image by summing 20, 30, or 100 signals, but you have to line these signals up before you can stack them. Both of the two main processes used to line these up are related to figuring out the near surface and subsurface velocities."

Costs cut sharply

The main seismic acquisition costs are equipment, people, time in field, and the cost of drilling dynamite shot holes, said Bahorich.

In the Zama, Alta., area, Apache makes 250 shots/sq km, and the typical dynamite seismic acquisition survey costs \$50,000 (US)/day.

Apache carried out three 3D surveys in Canada from January to March 2004, and total cost savings totaled about \$2 million. Development costs on these first three Explorer 860 units were less than \$1 million, and the buggies are far cheaper to operate than a dynamite survey.

The buggies can work 24 hr/day, while dynamite acquisition is often limited to daylight hours due to safety issues.

"Possibly we'll even shoot in the summer time in areas where traditionally we haven't been able to shoot in the summer time because of the difficulty of access and the terrain," Monk added.

The buggies needed only about a week of "debugging" once in the field, not bad for any R&D undertaking. Fuel lines and pumps froze, stalling operations at minus 38° F. in late January, but minus 20° F. did not pose such prob-

lems.

The instantaneous thumper data also save time versus Vibroseis, Bahorich noted.

"Vibroseis is a sweep. You vibrate 12-16 sec, then listen 3-6 sec; the weight drop needs no sweep time."

Also, first break energy is very subtle on Vibroseis records and extremely sharp on weight drop records.

Footprint reduced

One goal is to make each successive seismic survey less intrusive to provide the greatest chance that subsequent operations find it no more difficult to obtain regulatory permits and surface owner permissions.

Elimination of dynamite shot holes is a big plus. Passageways cut through trees need not be as wide for buggies as for shot hole drilling rigs and need not be cut in straight lines, Monk said.

Erosion and snow melt will erase the imprint of the base plate in a short time (Fig. 4). ♦