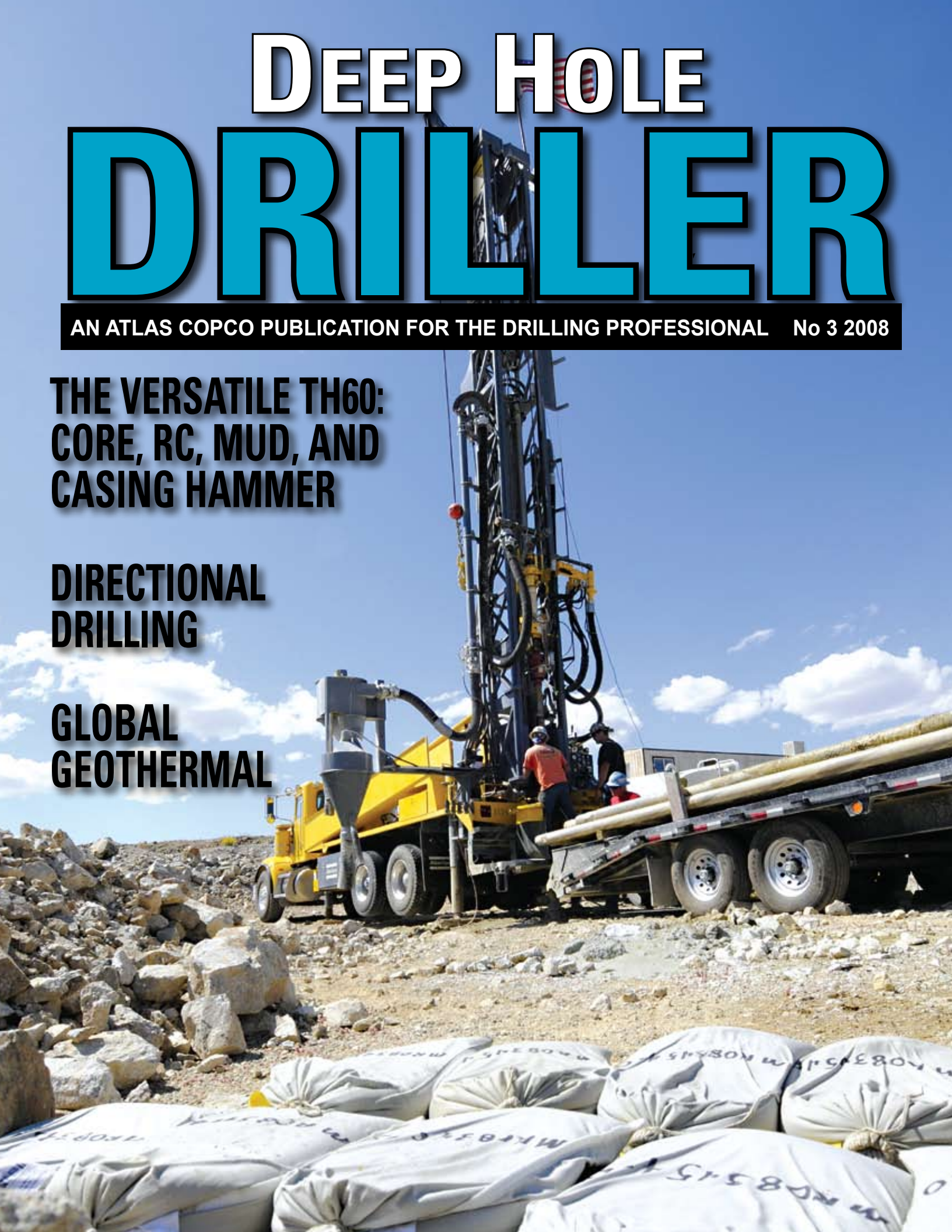
# DEEP HOLE DRILLER

AN ATLAS COPCO PUBLICATION FOR THE DRILLING PROFESSIONAL No 3 2008

## THE VERSATILE TH60: CORE, RC, MUD, AND CASING HAMMER

## DIRECTIONAL DRILLING

## GLOBAL GEOTHERMAL



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# TECHNOLOGY AND OUR FUTURE

Welcome to another issue of Deep Hole Driller! I don't have to tell you that this is a year we have a lot to reflect upon. It looks as though the U.S. election and global financial instability are taking their toll on our markets. If we listen to the media, the world is doom and gloom.

However, you and I know it isn't. Throughout history, people in the drilling industry have seen both good and tough times but with perseverance, they have made it through and become stronger. This is that time for us and we will persevere.

We recognize two significant anniversaries in 2008.

The U.S. National Ground Water Association (NGWA) is celebrating its 60th anniversary. The NGWA is made up of drillers, owner/operators, and drilling corporations — the NGWA is you. Throughout history you have provided the world with its most precious and needed sustenance of life — water. We both thank you and congratulate you.

Atlas Copco AB is celebrating its 135th year as a company. In addition to being an anniversary year, 2008 has been a year of record-breaking water well drill sales worldwide. We thank you, our customer, for putting your trust in Atlas Copco and making this success possible.

We are excited about the future. Our newly re-designed T3W and TH60 drills have rejuvenated our excitement with a whole new tier of productivity and applications. The RD20, which has been a leader in the 120,000 lb. hook load class of oil and gas drills, will continue to dominate with a new up-set pipe handling option in 2009. Our new, technologically advanced, Predator™ Drilling System for the oil and gas industry will be introduced at OTC in Houston in May of 2009. We expect it to take the market by storm and I invite you to preview this new drill at www.atlascopcooilandgas.com.

Yes, the challenges of 2009 will be great. But the successes will be even greater because once again, the entrepreneur, owner/operator, and driller will defy the odds and meet the challenge to provide water for life and energy-related materials to keep our economy strong.

From our family to yours, Atlas Copco wishes you a safe and successful 2009.

Sincerely,

**SCOTT SLATER**
Business Line Manager
U.S. Water Well and Oil & Gas

## DEEP HOLE DRILLER

Is published by Atlas Copco Drilling Solutions LLC. The magazine focuses on the company's know-how, products and methods used for deep hole drilling and the advancement of the industry worldwide.

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# INSIDE

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TH60 and RC50 hammer exploring for gold

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# A HIGHER PERFORMANCE

## *California driller excited about new features on the TH60*

**For California driller Scot Unterseher, the TH60 is all he has ever known. For 10 years he has worked for Fisch Bros. Drilling of Sebastopol, Calif., and knows the TH60 inside and out. Like many drillers, he knows how fast his drill does everything — drilling, tripping, winch speed. Even the sounds of the engine and compressor are familiar to him. So when he made the transition from the Classic TH60 to the newly redesigned TH60, he was unsure of what to expect … but he's not wondering anymore.**

Drilling in the coastal regions of Northern California presents a variety of geological challenges for drillers. Near the city of Petaluma, the Pacific Ocean is 20 miles (32 km) to the west. The formation shows that there was once ocean life this far inland and includes seashells 200 ft (61 m) below the surface. The sandy valleys and igneous hilltops that give the region's famous Sonoma and Napa Valley wines their renowned flavor also present huge variations for a driller. Pair that with the occasional earthquake and well development is anything but typical in northern California.

For this domestic well, the crew drilled a 300 ft (91 m) borehole that produced 5 gallons (19 l) per minute (gpm). Although there was an aquifer producing 15 gpm (57 l) between 60 and 80 ft (18 and 24 m), that zone needed to be cased and sealed. In that part of California, chicken farms dotted the landscape for more than 100 years. The chicken droppings left behind high nitrates, so wells for domestic potable water require a 100 ft (30 m) seal.

To protect the customer's existing home at the base of the hill, Fisch Bros' crew shoveled an extensive terrace system as the well was being drilled. When the foam reached the top of each dyke, the crew had to be ready with another mini-dam to control the flow.

Because California is an active seismic zone, wells cannot be sealed with cement, so bentonite is used. The percolation rate for bentonite is 1 inch (25 mm) per 100 years. Plus, in an earthquake, bentonite will seal itself, preventing surface contamination.

Drilling in this area is conducive to the TH60 because of the terrain and variation in drill methods: mud or air. The crews could drill with air one day and mud the next, depending on the well's location. Valleys this close to the ocean commonly produce 5 to 10 gpm (19 to 38 l), while company owner, Ed Fisch, said that just


Driller Scot Unterseher and owner of Fisch Brothers Drilling, Ed Fisch, pose with the company's new TH60.

15 minutes away in Sonoma, the clay formation could produce much more.

Fisch Bros. cases with PVC piping and backfills around the casing with sand. About 30 percent of the casing will get perforated. Once the well is drilled, cased, backfilled with sand, and sealed, the well will be flushed from the bottom. To do this, the crew extends a 1½ inch (38 mm) galvanized pipe to the bottom and flushes with air until the well runs clear.

One of the features Unterseher likes about his new TH60 is the air regulation feature. When flushing the hole in the past, pressure sometimes blew out the PVC casing. "The electronic air regulation is a real benefit that I like," said Unterseher. He acknowledged he could feather the butterfly valve with the Classic rig, but having the dial gives him much more control.

"Control is overall better on this rig," Unterseher pointed out. "Although the control panel is completely different, after a couple weeks I was comfortable with the changes and they have made me more efficient."

He pointed to the digital diagnostic gauge and pushed buttons showing the engine output, torque and compressor information. "Everything I need to know is right here," he said. Before, he could get information, such as engine data and fuel levels, in the cab, "but now I have it right here in front of me and I can concentrate on drilling."

Unterseher likes the increase in pull back over his other rig, too. "This one has 40,000 pounds (18,144 kg). That's 25 percent more than our other two-year-old rig, which could come in handy." The wells in this part of California are mostly in the 200 to 500 ft (61 to 152 m) depth, but Fisch also can do mountain work with the increase in pull back. "The deepest we've ever drilled is 1,240 feet (378 m), but with this I can go 1,500 ft (457 m) if I need to," said Unterseher.

When tripping out of the hole, Unterseher pointed out on the diagnostic readout that he can trip at 900 rpm, and said he runs about 1,500 rpm now when developing a well. With the old rig he would run at 1,800 rpm all the time because he couldn't regulate it. "The load-sensing hydraulics is a great feature for saving fuel. You can hear how much less the engine has to work when tripping. I have more power and use less fuel."

With the decreased engine rpm, Unterseher emphasized he doesn't lose speed either. "With this rig I'm tripping at idle faster than our other rig does at full throttle!"

Reducing engine output is a maintenance factor for Unterseher. "On-demand hydraulics verses running all out extends the life of the pumps and hoses, but it's cable life and greasing that saves the most headache," he said. With the old rig, Unterseher would replace a cable every six months, replacing one side each time. "With the bigger sheaves, you can see the cable gently turn over the top and with the pre-packed grease, I'm not greasing all the time either."

Unterseher's long list of other things he likes better about the TH60— from the mud adjustment lever that makes it easier to regulate the mud flow to the updated cab, complete with air conditioning, power windows and a smoother ride -- it was his overall assessment that summed it up best, "With this rig I can go in and out faster for less money. I am very pleased with this rig."

DHD 308

The electronic air regulation feature allows Unterseher to dial down the pressure when flushing the hole. He connects a 1½ inch (38 mm) galvanized pipe to drill pipe and extends it to the bottom of the well, cleaning the well from the bottom.


Unterseher shows off the new digital diagnostic readout. Although almost everything is in a new location on the new rig's control panel, Unterseher said the configuration is handier and it took only a couple weeks to get comfortable with it.

# ROCK EATER

## *Atlas Copco proves itself at Silver Peak for reverse circulation drilling*

**Staying on budget is always important, but the nature of exploration drilling and its many unknowns don't always make that possible. How equipment will perform in a formation is difficult to lay out on a spreadsheet. Even so, Golden Phoenix of Reno, Nev., is having no problem keeping the accountants happy.**

Golden Phoenix had to first determine if the best way to explore its Silver Peak, Nev., operation was to contract the drilling or to purchase a drill and hire its own crew. Because 23-year-drilling-veteran and Drilling Services

Silver and gold were discovered at Silver Peak in 1863 and 1865, and mining continued until 1941.

At left, Golden Phoenix's Jason Layton confers with Wayne Colwell over drilling operations at the company's property.

Manager Jason Layton was part of the team, the board gave in to the idea to go it on their own. "If Jason wasn't part of the equation we would have never gone this way," said Golden Phoenix's Senior Manager for Technical Services Wayne Colwell. That put lots of pressure on Layton to get it right.

Next, Golden Phoenix needed a rig that could do the job. "We looked at everything out there," said Layton. What it came down to was the service he would get from the Atlas Copco customer center in Sacramento, Calif., and how the Atlas Copco TH60 DH could be outfitted to work efficiently for Silver Peak's needs.

"The TH60 DH is really set up for RC (reverse circulation) drilling," said Layton. "With other rigs you have to touch three handles to do anything. With the TH60 you just have one." He made modifications so he could drill at an angle, but other than that, the rig is a standard 70,000 lb (63,500 MT) pull-back rig. Layton had experience with T3W and RD20 rigs, so the move to the new TH60 wasn't a hard one.

Layton likes the setup and performance of the TH60, too, stating, "It's got a clean deck if you have to work on it and there is less noise because you're so far from the engine." He is pleased with the 123-gallon (465 l) average daily fuel usage with the rig. "That's not bad for a 600-plus horsepower engine." he said.

An important factor in the fuel savings has been the electronic air regulation (EAR) system. "Having the ability to dial down the cfm or psi and fine tune the air output is a big benefit when RC drilling," said Layton. Just like all drilling, speed and the ability to move through rock depends on the formation, but with RC drilling, "The samples are the most important," emphasized Layton. "You have to really keep your eye on it." He can drill rods through limestone in three minutes and through granite in eight to 10 minutes.

In the six months from March to mid-September, Golden Phoenix put 1,400 hours on the rig and drilled 34,000 ft (10,363 m). "We expect to put 50,000 ft

Top Row Photos: Numbered bags and small container samples are taken every five drilled feet.

Bottom Row Photos: Plaster poured around the 5-ft (152 cm) deep pipe seals up the discharge line. When finished, a hammer "pop" on the pipe will break the plaster free, allowing the discharge pipe to come cleanly out of the hole.

(15,240 m) behind us before the snow flies," said Layton.

## PERFORMANCE SPEED

Golden Phoenix drills with a three-man crew: driller, pipe handler, and bagger. The bagger's job is to fill the sample bags and put a small sample in a tray. A sample is taken every 5 ft (152 cm).

With the new TH60DH, the crew has tried many different options for hammers. The fastest they could drill with a non-Atlas Copco hammer was 300 ft (19 m) in a 10-hour shift. With the QL50, the drilling speed increased to 500 ft (152 m) in a 10-hour shift. Then Atlas Copco salesman, Brian Walter, introduced them to Atlas Copco's new RC50 RC hammer.

"My guys weren't too happy with that hammer when we first put it to work," said Layton with a smile. "They were working so fast it took two guys to bag samples to keep up...it was really fun to watch. That hammer can really eat rock!"

Out of the box, the crew put 500 ft (152 m) on it the first six hours and it hasn't let up. The crew averages 500 to 800 ft (152 to 244 m) a day, depending on how many times they have to move. The most they've drilled in one day included 29 moves and 890 drilled ft (271 m). An average hole is in the 300 to 800 ft (91 to 244 m) depth.

When estimating drill costs for capital equipment, labor and consumables, the amounts haven't changed, but Layton is getting significantly more footage – with less fuel consumption – from the TH60 and RC50. "We are way under our projected budget," said Layton.

The sampling hole is drilled with a 5½ inch (140 mm) bit on the 5 inch (127 mm) hammer. When reverse circulation drilling, special pipe is used that has a 2½ inch (64 mm) inner pipe within the 4½ inch (114 mm) drill steel. Air passes through small slots between the inner and outer pipe and the cuttings come up the center of the inner pipe. Putting a bag under the wet sampler, the cuttings are collected.

"I really like this rig," said Layton, "and we really take good care of it. But if I had to, I'd buy another one just like it."

## METAL EXPLORATION

Colwell points out that the formation includes a granite structure with quartz, limestone, and alaskites. Silver was discovered in the area in 1863 and gold in 1865. Folds and domes of igneous and metamorphic rock are visible on the mountain face, which points to the geologically active area. A 375-ft (114 m) high cinder cone (extinct volcano) can be seen in the valley below the old mine works. Gold is found in the Mary limestone formation and quartz.

Today Silver Peak is an unincorporated town of less than 80 people, which includes the Golden Phoenix crew, located at the base of the mountain. Early in the last century, the town had a booming 15,000 inhabitants and a thriving mining industry. In the late 19th century miners hauled ore off the mountain with mule teams, which were replaced in 1906 with a 14,000-ft (4,267 m) aerial tram to the mill site at Blair, one of Nevada's many ghost towns.

Hoisting the RC50 DTH hammer in place.

From 1906 to 1941, more wealth was pulled from Silver Peak than Nevada's famous Comstock Lode located at Virginia City. Mining was halted because of World War II.

An estimated 56 miles (90 km) of underground workings are located on the mountain, which has shaft openings dotting the mountain face. In addition to exploratory drilling at Mineral Ridge, Golden Phoenix is in the process of preparing a feasibility study using data generated by the TH60 to support the anticipated restart of gold production at this fully permitted and bonded property.

Sampling indicates .08 pit-grade gold in the ore body, and Colwell says 2 to 3 ounce intercepts are not uncommon. In comparison, a century ago underground activities followed seams yielding .25 to .3 ounces to the ton.

DHD 308

On platform from front: Jason Layton, Atlas Copco's Brian Walter, Driller Todd Mecham. Left: Bagging samples is Bryan Searle, with Mark Lichius ready to fill the next sample pail. Wayne Colwell, behind the group, is inspecting the cuttings.

# Mapping THE TAR SANDS

## *Drilling in Canada's tar sands to define the formation is perfect work for the TH60*

**From central Alberta, Canada, near Fort McMurray and east, to yet unidentified places and unknown depths, is a varying layer of oil-infused sand. This stratum makes up what is known as the tar sands, or oil sands. To find the depth, thickness, and extent of the tar sand, Bertram Drilling Corp. of Carbon, Alberta, is using an Atlas Copco TH60 drill rig to define the formation.**

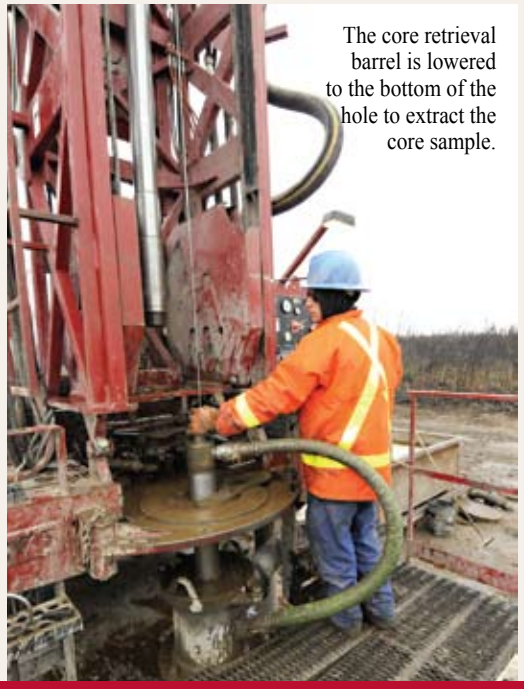
Bertram is an exploration company that incorporates different types of drilling in its business strategy. Its role is to identify where the tar sands are, and then recover samples which can be used to measure the potential of the formation. They run a fleet of 36 helicopter-portable drill units and several other types of drilling equipment including track, wheel and buggy mounted rigs. These smaller portable rigs can get places larger rigs can't, conducting seismic work. To do core work in the tar sands, Bertram uses Atlas Copco TH60 drill rigs. In total, the company has 17 rigs working in Canada and the United States.

The bulk of the coring work is done in a 90 to 120 day window of time, beginning at the end of December. For the most part, drilling in northern Alberta and Saskatchewan is winter work because much of the region is spotted with muskeg and swampy ground that can only be traversed when frozen.

The TH60 works well for this type of job because, for the most part, it is classic mud drilling work in heavy overburden and glacial till. The rigs are ordered without air compressors and equipped with a Centerline mud pump, a lightweight pump. Monument Machine Shop, Atlas Copco's distributor for Western Canada, supplies and installs the pump and takes care of Bertram's fleet of equipment. Darrel Skinner, sales manager for Monument, emphasizes service after the sale as being key to maintaining a good working fleet in Canada. Although

The safety line is removed prior to lowering the core retrieval barrel in the hole.

The 16-cutter core bit cuts the core sample.


The core retrieval barrel is lowered to the bottom of the hole to extract the core sample.


At the bottom of the retrieval barrel, a pronged metal piece called a basket keeps the core in the barrel.


Brothers Darrell Bertram and Brian Bertram and a TH60 rig. Except for the two rigs working at Axe Lake most of the company's fleet sits idle until December.

Bertram's crews usually stop work at -31° F (-35° C) — at that point steel becomes brittle — temperatures did reach -69° F (-56° C) last winter and the cold is hard on equipment.

## OIL SECURITY

Alberta's oil reserves are estimated at 280-300 billion barrels (Gb), but those numbers will become more than estimates through the work conducted by Bertram and others. As a comparison, Saudi Arabia's oil reserves are listed at 240 Gb. Total reserves for Alberta, including oil not recoverable using current technology, are estimated at 1,700-2,500 Gb. (zfacts.com, Wikipedia.com)

The tar sand formation is just that, heavy oil deposited in a layer of sand. The paleotopography, the topography of a given area in the geologic past, is dated to the lower cretaceous period. Below the tar sand is hilly limestone and the depth of the oil follows the contour of the land with thin and thick deposits.

According to Brian Bertram, "The tar sands are massive and only 10% have been quantified." The depths of the oil sand vary and are well within the pullback range of the TH60.

"It's our job to bring in the cores so others can extrapolate the data and do the reservoir analysis," said Bertram.

Drilling 5,250 ft (1,600 m) apart in a grid pattern, the formation is mapped out. Cores are then taken closer and closer down to 328 ft (100 m) until a clear picture is identifiable. Working just east of the Alberta border in Saskatchewan, northeast of Fort McMurray, the forested landscape allows coring work during the summer. Currently, a number of drilling companies are working in the region doing both exploration and SAGD drilling. (See side bar for explanation.)

## RETRIEVING THE CORE

Once identified, the oil can be recovered through one of two methods. Where it is shallow near Fort McMurray it is being scraped up with loaders. The deeper formation, like that at Axe Lake, will be recovered through SAGD operations.

Drilling starts out like a traditional mud drilled borehole. Bertram's drill supervisor, Wes McMann, at the Axe Lake Project said, "Drilling the surface hole is done with bentonite mud whereas the core hole requires a more slippery mud."

A surface hole is drilled with a 9⅞-inch (25 cm) tricone bit to a point above the formation where the spotting of tar begins appearing in the cuttings. This is called the core point. The hole is then

Inside the core barrel, the 2½ inch (6 cm) PVC pipe contains the core sample.

The TH60 rig works well for coring and mud drilling surface holes.

cased and cemented with 7 inch (18 cm) casing.

Once the surface hole is finished, the coring begins. Going back in the hole with a 6¼ inch (16 cm), 16-cutter, core bit at the end of 4½ inch (11 cm) core pipe, the bit is advanced through the formation. As the bit advances, drilling stops in increments from as little as 4 inches to 118 inches (10 cm to 300 cm) to retrieve the 2½ inch (6 cm) core sample. McMann said, “A quality recovery is when 95% of what was drilled comes out of the hole.”

When the bit is advancing, the core sample moves up and into the core pipe and then into a 10 ft (3 m) section of pipe, called a retrieval barrel. Inside the retrieval barrel is a 2½ inch (6 cm) PVC pipe that firmly holds the sample in place. At the bottom of the retrieval barrel is a pronged metal piece, called a basket, which allows the sample to move into the barrel. The basket secures the sample so it doesn’t fall back into the hole. Once the driller stops advancing the bit, a cable lowers a retrieval pipe into the hole. At the end of this section are fingers that lock into a landing ring on the top of the retrieval barrel. The retrieval barrel is pulled from the hole.

The sample length will be checked for length and geological properties and the process is repeated. Once through the tar sand strata, and at least 10 ft (3 m) into the limestone, the hole is complete.

“Our job is to define the oil formation,” said McMann. "The hole is done when we reach the bottom.”

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## STEAM ASSISTED GRAVITY DRAINAGE
## ENHANCED OIL RECOVERY

Over 90% of the world’s heavy oil and oil sands are deposited in Canada and Venezuela. Up to 90% of Canada’s estimated reserves could be recovered by steam assisted gravity drainage (SAGD) operations and 10% by surface mining.

In this process, two horizontal wells separated by a vertical distance are placed near the bottom of the formation. The top horizontal well is used to inject steam which rises, forming a large steam chamber above the well, and the bottom well is used to collect the produced liquids (formation water and oil). The rising steam condenses on the boundary of the chamber, heating and drawing out the oil to the production well. The process leads to a high recovery and high oil rate at economic oil-to-steam ratios (OSR).


Left, Drill Supervisor Wes McMann stands with Safety Advisor Adam Gresley-Jones.


## *Casing hammer makes easy work of glacial till on Wisconsin dairy farm*

**When Alfred Lee started milking cows, his farm was a typical Wisconsin dairy operation. Today the incorporated family business has embraced large scale farming practices and ventured into a much bigger operation than Lee ever dreamed about. Large dairy barns use water for many reasons, some more obvious than others. For cows to produce milk, it is, of course, necessary for them to drink water – about 25 gallons (95 l) each per day. At Norswiss Farms Inc., in Rice Lake, Wis., geothermal cooling is just as important as drinking water.**

In total, five wells will supply water to the Norswiss farm. Aqua Service, Inc., of Cameron, Wis., has drilled wells supplying 10, 30, and 50 gallons per minute (gpm). But, as the cow herd continues to grow, so has the quantity of water needed on the farm. With the first of the two 100

gpm (455 lpm) wells already completed for milk cooling and animal watering, the second 100 gpm well is currently being drilled and will be used for the cow cooling system. To cool the animals in the summer months, a misting system will be installed in the 350 ft x 1,000 ft (107 m x 305 m) dairy barn that is currently under construction.

The new barn will house 3,400 head of Holstein milk cows, with an additional 1,200 head in a separate barn. With 4,600 head consuming 25 gallons (95 l) per day, that equals roughly 42,000,000 gallons of drinking water per year. When temperatures heat up, cows get stressed. A research study published by Kansas State University, "Questions and Answers about Heat Stress," indicates stressed cows consume 6 to16 percent less food than thermal neutral lactating cows. This equates to a 30 to 50 percent reduction in the efficiency of energy utilization for milk production, according to the study. To evaporate 1 pound (454 g) of water off a cow's back requires 1,000 BTUs, which the study said comes out of the cow's body. As air is a poor conductor of heat compared to water, it is more efficient to evaporate water from a cow than to cool the air. Norswiss is installing misters and fans to cool the cattle, hence reducing cow stress in the hot Wisconsin summers.

The comparison in Alfred Lee's advancement in the dairy business is about as great as the drilling technology from when Jerome Wojtkiewicz started Aqua Service in 1969 with a cable tool rig. Today the full service drilling and well service company is operated by Wojtkiewicz's son-in-law, Jeff Haughian. The company has grown over the years with the purchase of its first rotary drill rig in 1975 and Wojtkiewicz mounting his first casing hammer in 1977.

Haughian compliments his father-in-law, who was only the second driller in Wisconsin to use the casing hammer. Although mostly self-taught, Wojtkiewicz mastered the technology to the point that, "not only did he create a successful business for himself, he has converted many other drillers to air rotary drilling with a casing hammer," said Haughian. Some of the drillers Wojtkiewicz has taught also operate Atlas-Copco drills.

"We've really got it all when it comes to rock in northwest Wisconsin: igneous, sedimentary and metamorphic," said Haughian. With sandstone being the most common bedrock they drill, it can be encountered from a few feet to nearly 400 feet below ground surface. "About 90 percent of the time, we advance our casing with the casing hammer right from ground surface, through the overlying mixture of sand, gravel, clay, cobbles, and boulders," added Haughian.

Most wells are cased with 6 inch (15 cm) steel from surface to the optimum water bearing formation, either sand and gravel or bedrock. Using the casing hammer is an advantage over mud drilling because it allows for greater borehole stabilization through the unconsolidated formation. Also, water from the unconsolidated aquifer can be analyzed as the casing advances. "If you're drilling with mud, you can't stop to test the quality of water at discrete places in the sand and gravel formation. We also feel that knowing exactly what the formation is greatly enhances the yield of screened wells," said Haughian. In this area, some unconsolidated aquifers have multiple water-bearing layers, each with its own unique water quality. The main water quality concerns are high nitrate or iron levels.

Residential wells in the area range from 40 to 400 ft (12 to 122 m) in depth. "It all depends on what the glacier put beneath your feet in a particular location," explained Haughian. Commercial and irrigation wells can be drilled deeper than residential wells to get the desired flow of water.

On the Norswiss farm, the 100 gpm (455 lpm) wells will run about 400 ft (122 m) deep. The initial 200 ft (61 m) will be mud drilled with a 10 inch (25 cm) bit, with 6 inch (15 cm) steel casing cement grouted in the 10 inch (25 cm) hole. "It is a Wisconsin well code requirement that a well producing 70 gpm (265 lpm) or more have at least 60 ft (18 m) of cement grouted casing," said


Aqua Services, Inc. is drilling a well for this 3,400 head cattle barn under construction. When not being used the casing hammer can swing out and lock open.

Behind Jeff Haughian you can see the 1,000 ft (305 m) long dairy barn which he is drilling a 100 gpm (455 lpm) well that will be used for a cow cooling system. They are mud drilling the first 240 ft (73 m).

Haughian. Before the casing is cemented, the casing hammer gives the casing a firm seat in the sandstone. Wells without cement grout are sealed with granular bentonite as the casing is driven to prevent groundwater contamination.

The casing hammer method of drilling Aqua-Service uses for residential wells is to advance the drill bit 2 to3 ft (61 to 91 cm) out in front of the casing, clean the hole with air and water, then pull it back into the casing before advancing the casing with the casing hammer. Once the casing is lowered to the bottom, the process is repeated. "You don't want to get too far ahead of the casing because you don't want deviation in the hole," Haughian said. The 640 lb (290 kg) weight on the casing hammer has no problem driving the casing into the smaller diameter hole. There are times, though, when friction becomes too great and the process has to stop, but according to Haughian, "Nearly 100 percent of the time, the casing hammer gets you to where you're supposed to be."

Aqua-Service has installed up to16 inch (41 mm) casing with their casing hammer, and different models are available based on the work to be done. The casing hammer and handling system were installed by Aqua's distributor, Atlas Copco's Milwaukee branch, when the new Atlas Copco TH60 drill was purchased. Unique to this rig is the swing-out rail system. The casing hammer travels on these additional rails, mounted to the outside of the tower. The rails hydraulically swing out, thus swinging the casing hammer out from over the hole, to allow for easier setting of casing and drill rod handling. Haughian uses the Weldco-Beales casing hammer, which he sells as a dealer. The other feature Haughian is impressed with on the new TH60 is the air regulation system. "It makes developing out a sand and gravel aquifer prior to screening so much faster when you're able to increase and decrease air pressure and volume with the turn of a button, rather than try to regulate it with engine rpm," Haughian said.

So, whether it's telescoping a screen in a sand and gravel aquifer, or driving the casing to a firm seat in bedrock, using an air rotary drill with a casing hammer is much the same as cable tool drilling.

"Ultimately, this process isn't much different than the cable drill my father-in-law started with 40 years ago," said Haughian. "Now we're just doing it 10 times faster."

DHD 308

Top Right: As casing is advanced, to protect the quality of the joint from the impact of the casing hammer, three passes with straps overlapping the joint are used. Here Haughian shows the hook that lifts the drill steel and casing in place.

Second Photo on Right: Advancing the casing with the drill bit allows testing of the water quality and flow in every foot of advancement.

Third Photo on Right: Jeff Haughian shows the internal workings of the casing hammer. The 600 lb. (272 kg) weight comes down on the casing. The cuttings are discharged from a 10 ft (3 m) hose that comes from the discharge opening.

Bottom Right: Cold well water is used to cool the milk in this radiator-type system, saving energy from the traditional tank cooling-system.

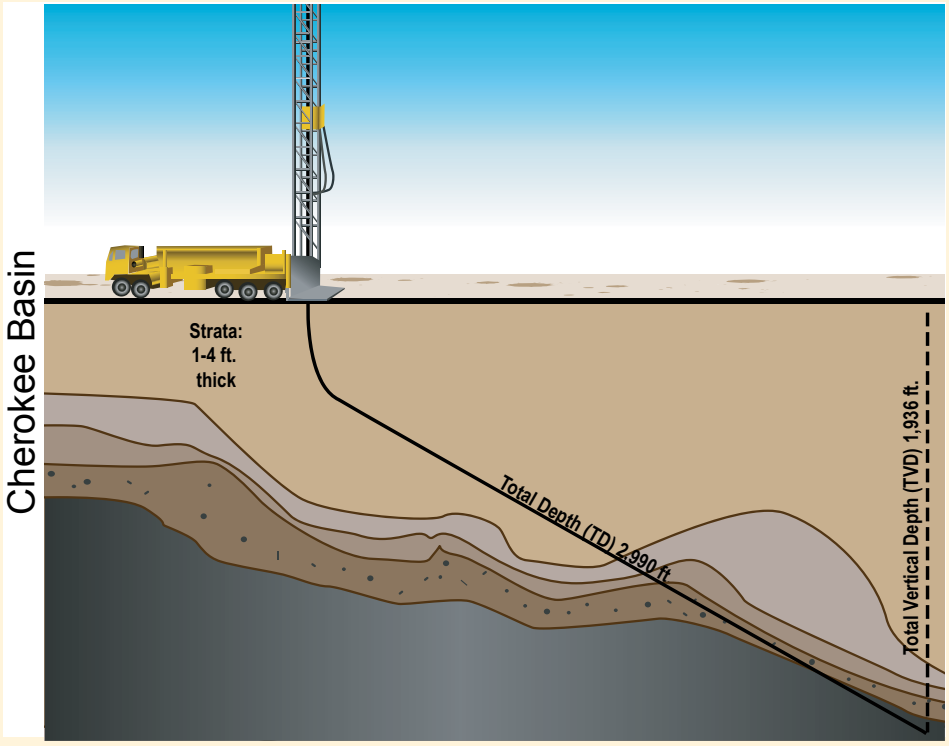
# Turning CORNERS

## *Using the RD20 for directional drilling in gas formations*

**Discovering ways to increase well output is an evolving science. Getting the most production from a well once revolved only around the size of hole or how the well was developed using various fracking or casing methods. Today optimal production is also determined by how a well is drilled. Pense Brothers Drilling, based in Fredericktown, Mo., is working with Scientific Drilling to develop a directional well in coal bed methane for Constellation Energy Partners (CEP). The Cherokee Basin reservoir in Osage County, Okla., has the potential to produce more when drilling directionally.**

As background, Pense Bros. operates 23 rigs, 13 of which are Atlas Copco RD20 drills in the five south central states of Utah, Colorado, Arkansas, Alabama and Oklahoma. CEP is an energy company marketing gas from three reservoirs, including the Black Warrior Basin, Woodford Shale, and Cherokee Basin. Scientific Drilling specializes in directional drilling, hiring out its advanced directional drilling skills to energy companies like CEP. The coal bed methane (CBM)

The drill site includes a large shaker box and two large mud pumps to deliver clean mud that will drive the directional mud motor.




gas potential of the Cherokee Basin lies in thin strata ranging from 1 to 4 ft (30 to 122 cm) thick, which allow greater recovery when boreholes are directionally drilled.

Larry Pense, manager of Pense Bros.' Glenpool, Okla., office, said that the formation and customer dictate the method of drilling. "Our job is to keep equipment operating on the surface. CEP tells us where to drill and the method to be used. Scientific Drilling drills the hole. I don't want to make it sound too simple, but our job is to go up and down and round and round and Scientific tells us what move to make."

Rodney Tate, drilling engineer with CEP, said, "The Cherokee lends itself to directional drilling. The formation is hardly ever flat and following it allows more contact area."

## DIRECTIONAL DRILLING AND THE RD20

It's no secret that the RD20 is the drill of choice in the south central states. The deepest Pense has drilled is about 5,600 ft (1,707 m), clearly within the pullback range for the RD20. According to Pense, the deepest well drilled to date in Oklahoma is 4,500 ft (1,372 m), with wells as shallow as 500 to 600 ft (152 to 183 m). Tate added, "Some wells are as much lateral as they are vertical."

Total Vertical Depth (TVD) measures the actual "straight down" depth from the ground surface to the bottom of a well. Total Depth (TD) includes all measured depth, from the surface to the end of the drill string. The gas formation is shallower on the eastern side of the basin than on the west, with a 700 to 2,300 ft (213 to 701 m) TVD variance. "We could have a lateral well from 0 to 2,000 ft (0 to 610 m)," said Tate.

Speed is the primary thing that makes the RD20 fit CEP's drilling program. "Anything that reduces time to TD is beneficial," according to Tate. "The RD20 is mobile and the auxiliary equipment has a smaller footprint." Tate said it could take a conventional rig 20 days to complete what an RD20 can do in two days – from rig-up to rig-down. "Daily rig costs are much greater for a double or triple conventional rig, and the leased footprint costs are much greater. Economically, this just makes sense," said Tate.

The RD20 works well for directional drilling. "Top drive is useful because it allows you to turn on top verses just rotating the mud motor. Also, the hydraulic pull back and pull down allow the driller to accommodate the formation," said Tate.

Scientific Drilling's directional driller, Walter Hancock, is the man on site working with Pense. His role is to direct the operation and give guidance to Pense's driller, Jose Pedraza. He reads the data feedback on his computer and keeps an eye on the cuttings, then conveys to Pedraza to turn the rotary head or increase or decrease mud flow which ultimately translates into directing the bit. The directional mud motor turns by the flow of mud moving through it. For example, 150 gpm of mud equals 70 rpm. "Directional drilling is much the same if you're at 2,000 or 12,000 ft (610 or 3,658 m)," Hancock pointed out. "It comes down to knowing the weight on the bit. That's how the hole talks to you," he said.

To drill at an angle, a mud motor is needed. Pumping mud down the string through the motor turns the bit. The position of the drill string determines the angle the hole will take. Pedraza has a gauge that shows him the direction he is going. Compare the round drill pipe to a 360 degree face of a compass: the gauge points to the location on the drill pipe that indicates the direction in which the bit is moving. (As seen in the photo, the bit is turned 240 degrees southwest.)

For Hancock, directional drilling with the RD20 is somewhat different from conventional rigs. The RD20 has 30,000 pounds of hydraulic pulldown, whereas, with conventional drilling, the weight of the string puts weight on the bit. Because the gas zones are much shallower in Oklahoma, the pulldown on the RD20 puts more control in the hands of the driller.

A gamma sensor within the drill string tells the operator the location of the bit and the formation's composition or contents. The sensor feeds data back to the driller's laptop in the doghouse.

Tate said, "As technology improves,

Walter Hancock directs the drilling from the feedback the gamma sensor sends to his laptop computer.

Pense Bros. helper Michael Casselman, Venture Drilling salesman Delaney Erickson, Pense helper Chase Waldrop, Pense driller Jose Pedraza, Scientific Drilling's directional driller Walter Hancock, and Pense helper Miguel Flores is in the front

sensors have moved closer to the bit and the motors have become smaller, and deciding which to use comes down to economics."

The gamma sensor used by Scientific is 28 ft (8.5 m) behind the bit, but Tate said it's possible to get within a few feet. In addition to the inclination and azimuth as the drill string advances away from the surface, the gamma sensor indicates the radiation in the formation, allowing the driller to follow the gas in the formation. Scientific's proprietary sensor technology is in a section added to the drill string that Hancock will only describe as a "hybrid sub that looks like two sections of pipe with a plastic piece in the middle." The non-metal section is needed to separate the sensor's antenna from the mud motor, keeping it from shorting out.

The gamma sensor is powered by three long lithium batteries. When the mud motor turns, the sensor sends information to the surface. When the rotary head on the drill turns the drill string, the sensor doesn't send information but it also does not use battery life. The batteries last about 150 hours. The advantage of turning from the surface and saving battery power is greater time in the hole and less time spent tripping.

Drilling in the Cherokee Basin is fast drilling. Using a 7⅞ inch (20 cm) Polycrystaline Diamond Compact (PDC) fixed cutter bit, the crew makes good time, as the formation is predominantly shale. The average well in this region is about 3,000 ft (914 m) to TD and takes about three days, according to Pedraza.

Like all drilling, the speed is dictated by the formation, and Hancock said that he is averaging 26.1 to 36.15 ft (8 to 11 m) an hour during the time the job was photographed, but that it has been as high as 216 ft (66 m) an hour on this well. Moving through coal seams, for example, is very fast because the coal is soft and the cuttings float so they come out of the hole fast.

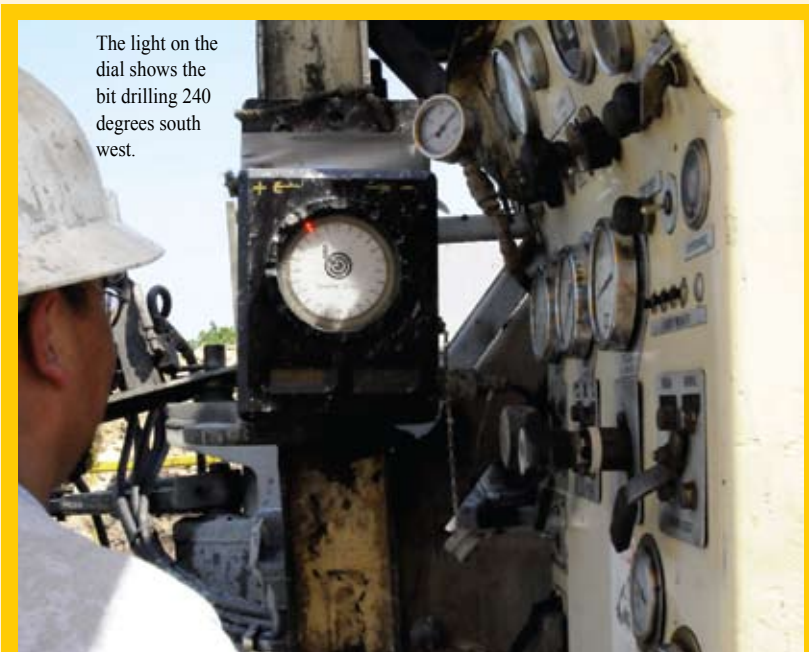
It is optimal to move through the gas zone as quickly as possible to avoid damaging the formation, which could impede gas recovery. Although the RD20 is capable of 30,000 pounds of pull down, Hancock said he works with Pedraza to pull back on the drill string, putting no more than 20,000 pounds on the bit.

Transitioning to a top drive rotary head rig took some getting used to for Hancock because the hydraulic gauge tells him the weight on the bit. On a kelly drive rig, the weight indicator on the string and pump gauge tells Hancock how fast to go. Complimenting Pedraza, Hancock said he's made the transition easier, "Jose is a good driller and he understands how all this [directional equipment] works."

Drilling this hole, the crew will set and cement 8⅝ inch (22 cm) surface casing to 120 ft (37 m). When drilling resumes, about 60 ft (18 m) past the steel casing, the sensor can be used. This is where Hancock will begin turning the corner. He will steer the bit at a 20 degree angle per 100 ft (30 m), increasing to 40 degrees, then 53 degrees to TD. The TD will be 2,990 ft (911 m). The TVD will be 1,936 ft (590 m) and is expected to pass through four gas zones.

**DHD 308**

The externally upset (also called EU or bottleneck) drill pipe requires a special hydraulic breakout wrench to hold and add pipe to the drill string. The bottleneck pipe is more flexible and the smooth joints take the turn better than standard internally upset (IU or flush joint) pipe.



The light on the dial shows the bit drilling 240 degrees south west.


# BOTTOMS UP

## *Gasco Drilling Finds Success with New CaliberXD™ Diamond Button*

**If something is worth saying once, it is worth repeating. Chris Ratliff did just that when talking about Atlas Copco's new diamond button bit, the CaliberXD. "This new 6½ inch (165 mm) diamond bit is the most impressive thing I've seen in quite a few years. It's the best product I've seen in years," he repeated with conviction.**

Chris Ratliff manages the drilling operations for the family-owned company, Gasco Drilling, Inc., out of Cedar Bluff, Va. Originally, Chris' father, Ben, operated a water well business with his brother, but saw the opportunity in gas and went his own way.

At the time the company began, drilling for gas was mostly tricone drilling. "Since the late '80s – early '90s – we could see top-head drive [hammer] drilling would be the future with a hard abrasive formation," said Chris Ratliff. In the 20 years since they began business, many have tried to enter the market, but couldn't deal with the hard rock. "Competition tries to come in and gets their lunch handed to them," Ratliff said with a smile.

Having the ability to hammer drill isn't enough, though, for Gasco. "Atlas has been a good partner for the last 20 years. They are willing to work with us…and some of our crazy ideas," said Ratliff. "We are a business that likes to try new things:

▲ Chris Ratliff (left), Tony Funk (back) with Keystone Drill Services and Jeff White with Atlas Copco holding the CaliberXD diamond bit.

bit structure, hammer modifications, blow tubes." Nothing is out of bounds for the constantly adapting company.

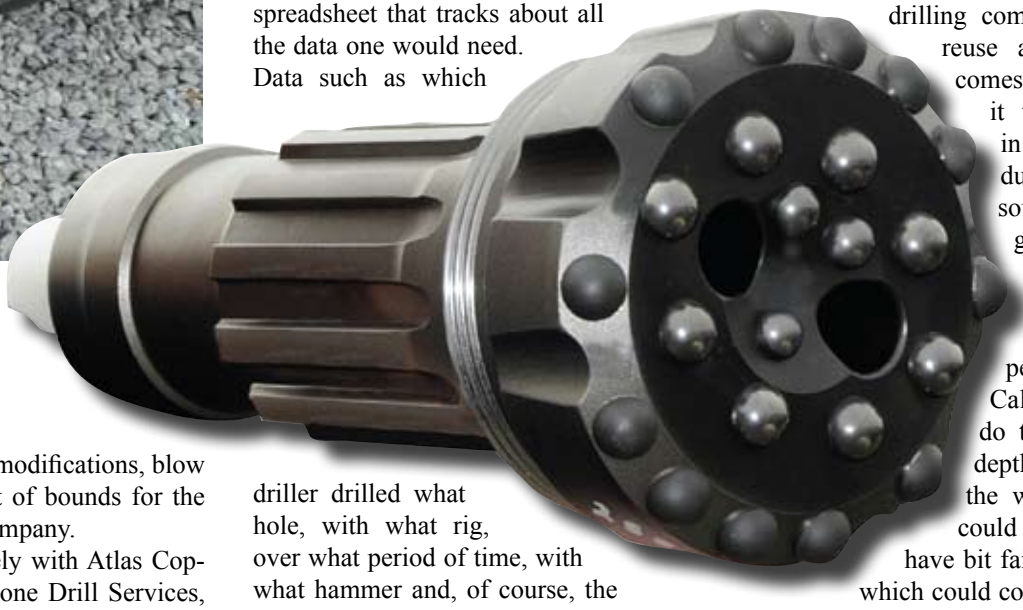
Gasco works closely with Atlas Copco's distributor, Keystone Drill Services, and sales representative, Tony Funk, out of Keystone's Norton, Va., office. Feedback is constant between Ratliff and Funk. "The drillers for Gasco are some of the best I've worked with. They feed the information to Chris who feeds it to me – air flow, face wash, every detail is looked at," said Funk. Funk said that Ratliff knows the life expectancy of a bit in each of the formations in which they drill and with that knowledge, tools can be redesigned for better performance.

For hard rock drilling, Gasco uses the Total Depth (TD) and Quantum Leap (QL) series hammers. In the 6-inch (152 mm) class Gasco uses the TD60 and the TD85 in the 8-inch (203 mm) class. For surface work with 12¾ and 16¼ inch (324 and 413 mm) bits, Gasco uses the QL120. "Because Gasco does so much business, they are always trying out competitive products and testing new tools. We pay lots of attention to their needs and make sure we have the best tools available. For their production work, the TD60 is the fastest, most productive hammer out there for high pressure air drilling – no one can touch it," said Funk.

That's why, when Atlas Copco needed to test the new CaliberXD diamond bit, Gasco was the perfect candidate to put it to work. "We are a bottom up operation. It all starts at the bottom of the hole with a strong button, strong bit, strong hammer… if there is a piece that is weak we'll find it," said Ratliff.

## MAKING FOOTAGE

Chris Ratliff charts everything. He has a spreadsheet that tracks about all the data one would need. Data such as which driller drilled what hole, with what rig, over what period of time, with what hammer and, of course, the footage of each bit. Ratliff pointed out, "The solid average over the last 20 years on a bit is in the 4,000 ft (1,220 m) range." Enter the CaliberXD bit. Since testing began, Gasco has had many holes over 5,000 ft (1,524 m) with the deepest TD at 5,800 ft (1,768 m).



The big advantage of the CaliberXD is that the hole can be drilled with one bit. "Having the diamond bit allows me to drill the entire bottom hole in one run. It takes one shift to trip and go back in if I need to change bits," said Ratliff. He also pointed out, "Tripping costs time off the bottom, but it's also hard on the guys." Ratliff compliments his crew's hard work, but he knows that working harder doesn't make more money, working smarter does. "The more time we spend on the bottom, the more productive we are for our customers – that makes us more profitable."

It comes down to the bottom line, and footage is what counts. "We are a footage contractor and below the 7 inch (178 mm) casing is where we are profitable. The new diamond bit is better for us because it means more drilling with less rigs and that means more profitability," said Ratliff.

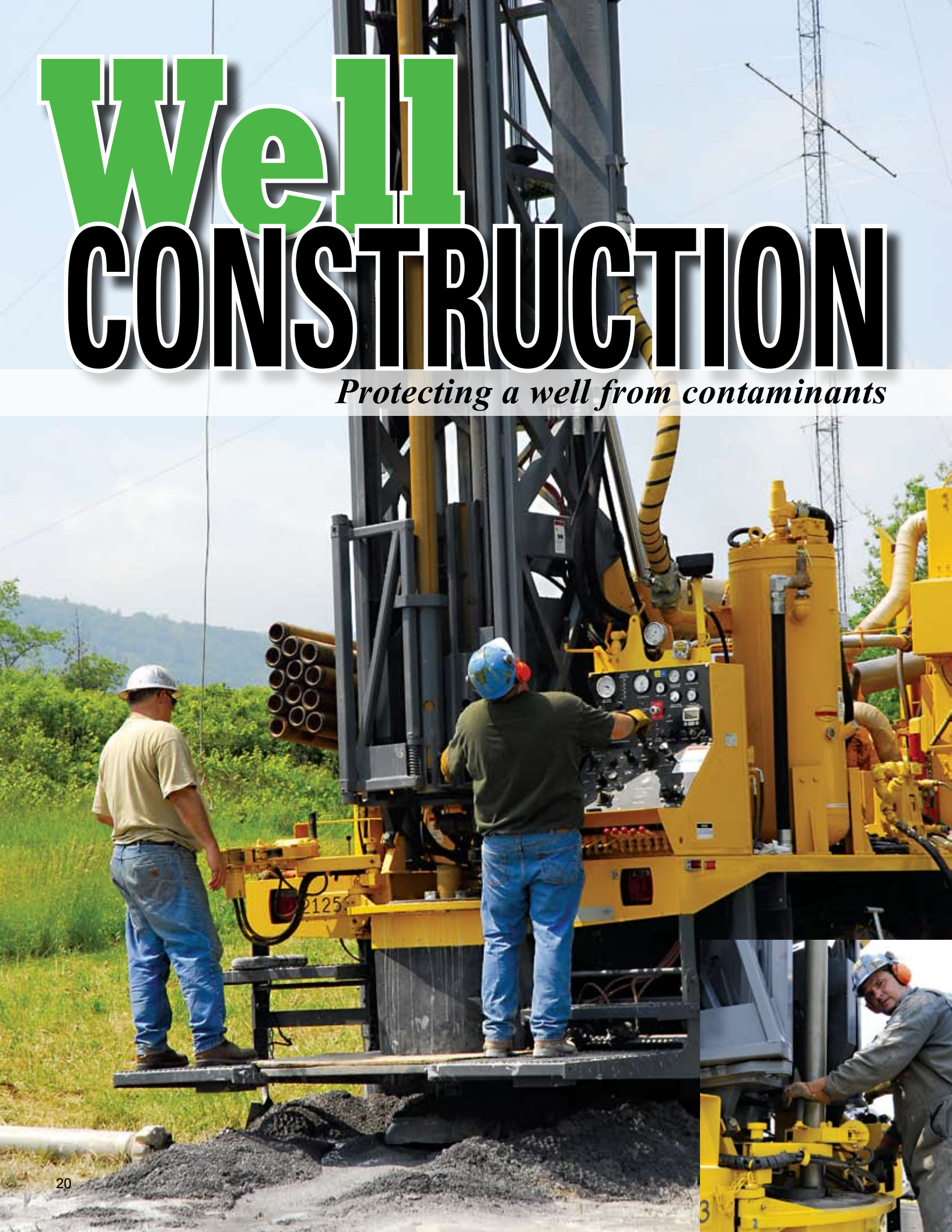
What's good for Gasco is also good for its customers. Ratliff explained, "Having the right equipment helps our proficiency and reliability over the hole. Our customers like this because when we come in on time, it helps them with their scheduling. If you miss your spot on the frack schedule, you go to the bottom of the list. Our proficiency gets the gas to market as quickly as possible."

Gasco, like most gas drilling companies, doesn't reuse a bit. Once it comes out of the hole it won't go back in for a gas production well. In southwest Virginia, not all holes will go to 5,800 ft (1,768 m) but if 90-95 percent do, the CaliberXD will do the job to total depth. For Ratliff, the worst thing that could happen is to have bit failure in the hole which could cost time cleaning the hole or losing the hole all together.

Even though the standard for Gasco is the 6½ inch (165 mm) bit, the company has even tried the new diamond buttons in the 8 inch (203 mm) class bit and found success. "In the future, I don't want to see anything else in my bits. I've tested other new bits; this is the answer most [manufacturers] have been promising. This is the best button on the market." And for a guy who is not afraid of repeating himself, Ratliff finished with, "This bit is the answer." DHD 308

# Well CONSTRUCTION

*Protecting a well from contaminants*



**How many drillers would have the confidence to take delivery of a new rig and then drill a well in front of more than a hundred of their peers? This happened recently in Pennsylvania when Grant Fritz and Gary Tyler took Fritz Brothers Drilling's new Atlas Copco T3W rig to drill a well for the Pennsylvania Ground Water Association's (PGWA) annual summer meeting. The meeting's purpose was for training and continuing education for fellow drillers on the technique of proper well construction.**

The state of Pennsylvania reports having the second highest number of residential wells in the nation. The PGWA estimates that more than 15,000 new water wells are drilled annually, with 4.5 million people in the state using ground water as their potable water source. Attending the annual meeting were over 150 drillers and 30 or so employees of the state's Department of Environmental Protection agency.

The mission of PGWA was to educate drillers on common and safe practices. The well construction that was demonstrated with the T3W was for a 400 ft (122 m) well that would be used by Penn State University for irrigation purposes on its agricultural property.

The focus, which is universal regardless of your region's surface casing depth requirements, is to seal the well to eliminate the potential for E.coli bacteria, nitrates and other surface contamination. This demonstration taught how to grout surface casing to 60 ft (18 m). It is understood that each state has varying regulations, but the purpose was to demonstrate how to get on a site and finish a well in one day.

As a comparison, in Wisconsin, a well requires a cemented seal in sand and gravel to 25 ft (8 m) and that goes to 30 ft (9 m) in sandstone and 40 ft (12 m) in quartzite. In earthquake prone California, cement is not used because it would crack. Bentonite is required up to 100 ft (30 m) in some nitrate rich areas because it will stay sealed and has a one inch per 100 year percolation rate.

The grout being used is neat cement with bentonite and a polymer which has a fast set up and 1,800 lb (816 kg) sheer strength. Once the product is mixed, it takes just a few minutes before it is solid and unworkable. Again, depending on the region, different products are available and required. As an example, other products would be better to extend the life of the grout in highly acidic ground.

When drilling the well, a 6 inch (15 cm) casing was set in a 10 inch (25 cm) hole to 60 ft (18 m). A PVC pipe, called a trimming pipe, was screwed together in 10 ft (3 m) sections to the bottom of the hole. The bags of material were mixed and pumped to the bottom of the well. Once the grout was in the hole, drilling could continue. A boot at the bottom of the casing kept grout from entering the casing.

Hard, consolidated rock is predominate in the Northeast. Atlas Copco's QL60 down-the-hole hammer is very popular because of its hard-hitting, fast drilling traits. In this area, Fritz got a penetration rate up to three ft a minute.

Back to where this started, how many guys would start up a new rig in front of their peers? Fritz and Tyler had no problem firing up the new T3W and even had the opportunity to show off the new rig's features to other drillers. "I absolutely love the feed system," said Fritz. He also complimented the bigger sheaves and no grease fittings, as both features will reduce his time spent on maintenance.

And with a large crowd looking on, Fritz said the rig is also much quieter because it runs at a lower RPM. "I like the way you regulate the air; there are defiantly many pros to this new rig," said Fritz.

The day was planned as a complete learning experience. The PGWA brought in a motor carrier officer to review proper Pennsylvania regulations. Dave Stackhouse, who had brought his water truck in to assist Fritz drill the well, offered up his rig to the officer for review. Ultimately, the day ended with everyone having the opportunity to take away something educational.

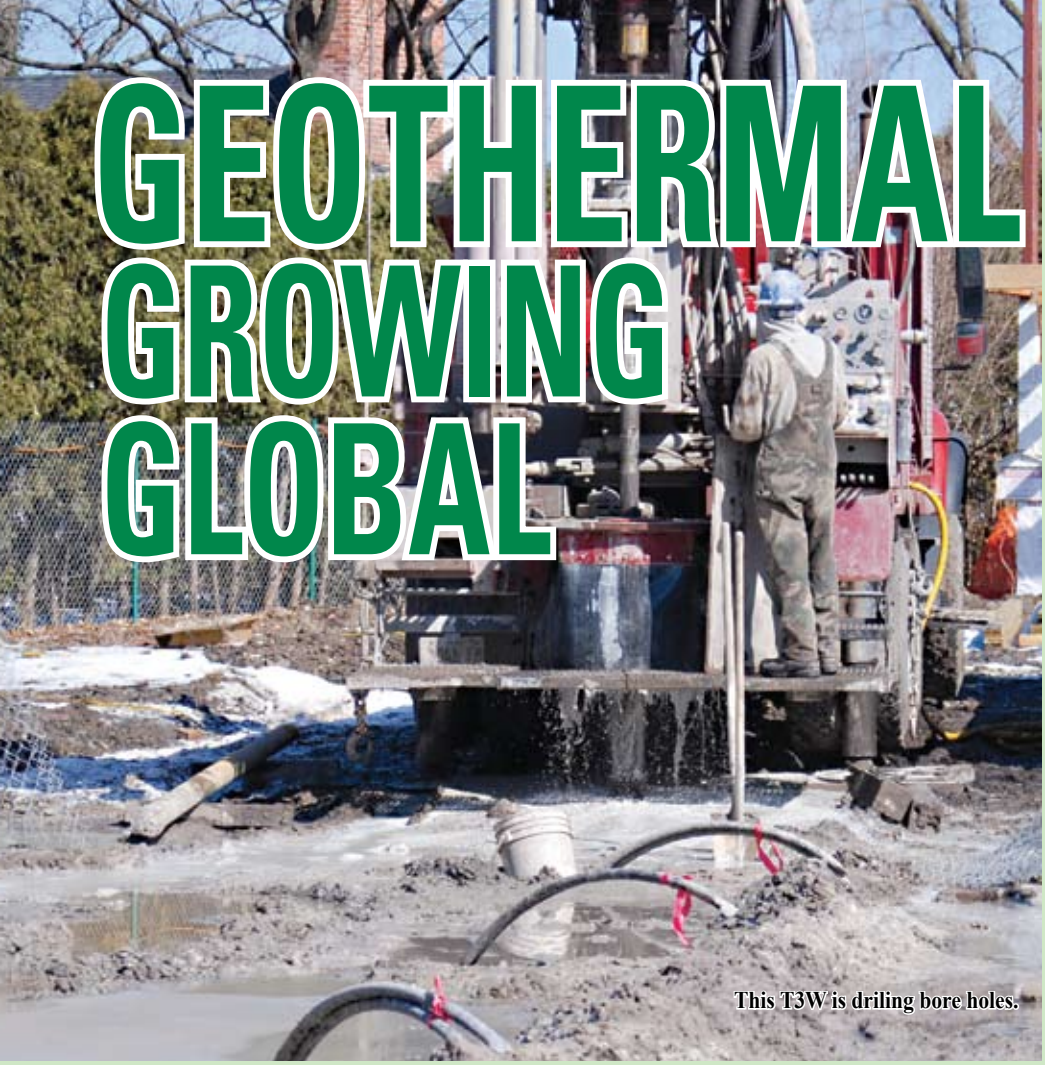
DHD 308

◀ Single rod handler swings under the rotary head, allowing quick handling of pipe.

◀ Bottom Right: Grant Fritz with his new T3W.

▼ From Left: Gary Tyler, Todd Singley, Dave Stackhouse, Dave Bruce, Dale Titman, Dave Ortman and John Davenport. The group drilled the well for the Pennsylvania Ground Water Association's training event.

# GEOTHERMAL GROWING GLOBAL



This T3W is driling bore holes.

**Geothermal energy is heat radiated from the earth's core, which is about 4,000 degrees F, but radiating out between 41 and 86 degrees F (5 to 30° C), depending on the geography. As energy costs rise and fossil fuel resources decrease, renewable sources such as geothermal energy are becoming more popular. While many Deep Hole Driller readers have been doing geothermal work for years, others are just getting started. The following article shows how Atlas Copco rigs are used around the world, and also looks at the market opportunity from a global customer and heat pump manufacturer's perspective.**

Of the benefits for using geothermal heat, the most common is reduction in energy costs. Geothermal heat pumps use 25 to 70 percent less electricity than conventional heating or cooling systems.

The concept of geothermal heating or cooling is simple: by passing liquid through pipes in the earth, the temperature of that liquid rises or falls based on the energy extracted by a heat pump while above ground. The constant ground temperature is used to heat or cool the ambient temperature above ground. In summer months, the cool ground chills a warm room and in the winter, the warm ground heats a room.

Of the major renewable energy sources: wind, solar, biomass and geothermal, it is geothermal that is the most readily available. Unlike the other forms of renewable energy that require expensive or specialized equipment – or use elements outside of an individual's control such as wind or sun – geothermal energy is under everyone's feet and simply takes drilling boreholes to extract the energy. The most common non-electric use of ground source energy in the world is the geothermal heat pump, which looks much like a forced air furnace, and is used by 3 to 4 million Americans in their homes.

The payback for the customer's initial investment is currently projected at five to six years, but that varies depending on installation and energy costs. When installing a system in Europe, it's reported that companies are giving a 100-year warranty for the loop field. One U.S. manufacturer of plastic tubing offers a 55–year product guarantee.

In addition to those using individual heat pumps, another 3 million people in the United States receive electricity generated from geothermal power plants operating in seven states. The United States produces less than half of the 37,205 GWh generated annually by geothermal power plants. The International Energy Agency estimates that nearly 50 percent of global electricity supplies will have to come from renewable energy sources if the world can halve carbon dioxide emissions by 2050.

For global interest to increase, corporations will have to raise awareness and let the public know how available geothermal can be. Atlas Copco distributes its drilling equipment worldwide through 60 customer centers to nearly 150 countries. Products are manufactured in plants in the United States, Sweden and India.

The standard geothermal borehole depth varies by region, but is generally not deeper than 600 ft (200 m). The standard borehole depth in the United States is between 200 and 400 ft (61 and 122 m) and diameter depends on which tooling works best in the formation. China reports that a 5 inch (130 mm) diameter hole is most common with depths of 430 to 600 ft (130 to 180 m).

An Atlas Copco customer in Weifang, China, Fourth Prospecting Team of Shandong Coal Geology Bureau (Fourth Team), operates a geothermal company. Fourth Team has purchased 10 Atlas Copco TH10 drills. These drills have increased Fourth Team's productivity significantly. Mr. Liu Zhigang, vice manager with Fourth Team's geothermal company, stated, "Previously we used other water well drills and failed several times. After trial use and tests, we found that the product [TH10] has very high rates of efficiency. To us, high efficiency means high profits."

## COMMERCIAL GROWTH

Sweden's retail giant, IKEA, has 229 stores in 24 countries. IKEA has launched a worldwide energy-

saving campaign designed to reduce its energy consumption by 25 percent. Part of this campaign includes the installation of geothermal heating and cooling systems. So far, about 10 facilities in Europe have completed installations and another 10 are due to be installed in the next 12 to 24 months.

John Harris is project manager for the "IKEA Goes Renewable" program and said, "We believe that when everything is correctly dimensioned – the depth of the well, the ground source heat pump and the pipe system relative to the size of the building – then that is absolutely the most energy-efficient system you could have. If we didn't believe that, we wouldn't be doing it in country after country."

About 100 boreholes are required for a typical IKEA facility, such as the store in Corsico, Italy. The holes were drilled to 330 to 650 ft (100 to 200 m) depths to provide 1,326 kW of heating and cooling. At its recently opened warehouse in Karlstad, Sweden, 85 percent of the heating requirements and 75 percent of the cooling is now supplied by heat pumps. In total, 101 boreholes, each 394 ft (120 m) deep, provide 1,200 kW of heating and 800 kW of cooling. Energy consumption is expected to be reduced by 76 percent per year and carbon emissions by 2,200 tons (2,000 tonne).

## GLOBAL OPPORTUNITIES

German-based Bosch Thermotechnik GmbH is a leading manufacturer of heat pumps with 18 plants, producing the brands Bosch, Buderus, Junkers and FHP. Bosch also owns the Swedish brand IVT which is the leading producer of heat pumps in Europe. As a testament to the industry's growth potential, IVT recently inaugurated a new Swedish plant with capacity for 80,000 heat pumps per year. Bosch's purchase of U.S. manufacturer, FHP, was also a focus on growth.

Martin Kueper is the general manager of FHP Bosch in Florida. He said, "Initially, much of FHP's production went to regional markets, but today the company has evolved into a global company shipping products throughout the United States as well as Canada, Europe, Asia, Central and South America, and the Caribbean."

"We are seeing remarkable opportunities for growth," Kueper pointed out, mentioning Africa specifically as a market showing double-digit growth in recent years. He said, "Energy savings potential for water source and geothermal heat pumps are being more and more recognized in many countries, especially in the commercial market."

*"We are seeing remarkable opportunity for growth."*

Martin Kueper, General Manager, FHP Bosch

China, like the United States and European countries, is making an aggressive effort to protect the environment and reduce the impact of high fuel prices. In China, roughly 100,000 geothermal wells are drilled every year. Subsidies are being offered to developers in Beijing and other areas of China to encourage more use of heat pumps. In 2006 Sweden drilled 40,000 geothermal wells. In the United States there are 1 million homes and businesses operating on geothermal heat pump systems, with more people encouraged to use them through incentives. United States geothermal incentives and tax credit or tax exemption information is found at www.dsireusa.org.

FHP's Kueper mentions other places in the world where geothermal is on the rise too, pointing out that Korean and Indonesian governments are very active in promoting the use of geothermal applications.

For companies that are willing to get to the core of the geothermal business, the opportunities for increasing business are endless.

*Information for this story was provided by the International Geothermal Association, the Geo-Heat Center in Klamath Falls, Ore., and from other sources mentioned within this text.*



**Atlas Copco is about to launch in the United States the Mustang 4-F1. This rig can get where truck-mounted rigs can't, such as a customer's remote location and even the basement of an inner-city high rise. The Mustang 4-F1 is meant for geothermal well drillers and is designed for low fuel consumption. The Mustang 4-F1 is further helpful on job sites because rock cuttings are blown directly into a waste container, reducing debris. On site, the rig makes its way around houses and gardens with minimal disturbance to the property. It is efficient to operate, ergonomically designed and easy to use.**


**Currently, the TH10 is the most common Atlas Copco drill in the developing countries of Africa, and popular because of its price in Asia. It is also versatile and can drill with mud or auxiliary air, like Atlas Copco's high pressure XRXS 1250 compressor.**

**All products made in Atlas Copco's Garland, Texas, facility are used for geothermal wells. Carrying 300 to 400 ft of drill steel on the rig allows for fast drilling of geothermal wells. The T2W, T3W, TH60 or T4W rigs offer drillers high productivity for the least cost per drilled foot. Selecting a rig comes down to pull back as it relates to geology, topography because mobility is a must and drilling method using air or fluids. Mud or foam may be necessary to maintain the holes structure whereas drilling with the rig's on-board air and a DTH hammer is the fastest method.**

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