Many bedrock formations, especially those that have weathered and decomposed over millennia of geologic time, today have a thick overburden composed of sand, silt, clay, and remnant boulders of the underlying bedrock. Often this overburden is unstable, and it caves in before the casing can be installed in the borehole. Re-drilling the same 10- or 20-foot caving zone again and again does not always get the hole to stay open, and it takes time and fuel that reduces the net income on the job. The case-as-you-drill method also provides an important safety benefit, because without any casing in the hole, a caving zone can collapse up to the ground surface, undermine the drill rig support jacks, and cause the drill rig to tip over.

A drill rig that can advance steel casing with the air-rotary drill bit can overcome these caving overburden conditions and safety issues. The casing keeps the hole open, while the hammer bit breaks up and drills through the boulders in the caving overburden. When there are no boulders in the overburden, the air cleans the hole as the casing with a special drive shoe (with carbide mini-buttons) is rotated into the overburden with no bit hammering at all. This innovative drilling and casing advancement technology is applicable to both drilling water-supply wells and to drilling geothermal boreholes in a loopfield.

The Pennsylvania Ground Water Association demonstrated how the case-as-you-drill innovative technology works at their June 2012 Summer Field Conference in State College, Pennsylvania. The drilling site was on the caving overburden developed on the Gatesburg Formation sandy dolomite bedrock, which, because of its caving overburden, is one of the most difficult to drill bedrock formations in all of Pennsylvania. The Gatesburg Formation sandy dolomite bedrock at this site has several hundred feet of silty, clayey, sand overburden that contains layers of iron ore and remnant quartzite sandstone zones. The commercial geothermal loopfield that was constructed at this location had to use mud-rotary drilling to overcome these caving overburden conditions.

Many residential water wells constructed in the Gatesburg Formation start out with a 10-inch surface casing, and then telescope down to an 8-inch, and then a 6-inch, and then a 5-inch casing to get through the caving overburden. These residential water wells may cost more than 30 thousand dollars when completed. This particular demonstration site was chosen to give this new case-as-you-drill technology a major challenge. This technical article explains how this case-as-you-drill technology overcame the challenge of the Gatesburg Formation with ease, and shows, step-by-step, how this innovative drilling technology works.

The drill rig used in this demonstration was a Schramm, Inc. model T450GT air-rotary, track-mounted, drill rig with the GeoCase™ casing-rotator option. The casing-rotator option is a special drill table that contains a rotating mechanism with jaws that grip either a 6-inch or an 8-inch diameter steel casing. This special drill table has a 7-foot vertical travel within the mast to advance (and withdraw) the steel casing. The deck compressor is rated at 1,050 cubic feet per minute (cfm) of air at 350 pounds per square inch, and we used a down-the-hole hammer for this drilling demonstration. Because the steel casing is advanced right behind the drill bit and down-the-hole hammer, the air and drill cuttings are returned to the ground surface inside the steel casing. Therefore, this drill rig has a diverter that sits on top of the steel casing and diverts the air stream and cuttings through a 5-inch diameter hose to a cyclone that is mounted on the side of the drill rig. The 1,050 cfm of air and the drill cuttings swirl around inside the cyclone where the centrifugal force of the swirling and gravity cause the drill cuttings to discharge from the bottom of the cyclone and cause the air to be separated and discharge from the top of the cyclone.

The step-by-step operation of this drill rig is as follows:

1. A button-bit on a down-the-hole hammer are loaded into the special drill table.
2. A diverter is installed below the top head. (see photo A)
3. A drill rod from the carousel is threaded onto the top head.

4. The tilting-top-head feature is used to tilt the drill rod out from the drill rig until the bottom end of the drill rod is a foot off the ground. *(see photo B)*

5. A casing elevator and the hoist line on the drill rig are used to pull a length of steel casing onto the end of the inclined drill rod and up into the casing connector collar on the bottom of the diverter. *(see photo C)*

6. The 3 pinch-bolts that hold the steel casing into the connector collar on the bottom of the diverter are tightened to hold the steel casing into the diverter. *(see photo D)*

7. The top head, the steel casing, and drill rod are raised until the steel casing and drill rod are in a vertical position.

8. The top head with the diverter suspended below it are lowered to insert the steel casing down through the drill table.
9. A special drive shoe with carbide mini-buttons is arc-welded onto the end of the steel casing. *(see photo E)*

10. The steel casing is lowered to the ground surface and the cables that suspended the diverter below the top head are disconnected.

11. The gripping jaws in the drill table are engaged and the steel casing is rotated and pushed into the overburden to a depth of 2 or 3 feet. *(see photo F)*

12. The air compressor is engaged and the button bit and down-the-hole hammer are advanced out ahead of the bottom of the casing. This out-front position of the bit and hammer cylinder ahead of the steel casing creates a larger annular space within the casing because only the drill rod in inside the casing.

13. The drill cuttings are carried by the 1,050 cfm of air up through the steel casing, through the diverter and hose, and into the cyclone. The cuttings exit from the bottom of the cyclone and the air exits from the top. *(see photo G)*

14. As the steel casing is advanced with the drill bit and hammer, it is rotated in the opposite direction of the drill bit. Because the drill bit is out in front of the end of the steel casing, most boulders within the overburden are broken up into small chips. The mini-buttons on the special drive shoe allow the drive shoe to enlarge the hole the bit creates through a huge boulder or zone of remnant bedrock within the overburden. The drive shoe is not used out in front of the drill bit to “core through” boulders or zones of bedrock within the overburden.
15. The casing gripping jaws inside the special drive table are disengaged, and the special drill table is raised to re-engage the casing gripping jaws further up the steel casing because the vertical stroke of the special drill table is 7 feet.

16. When the top of the steel casing is just above the top of the special drill table in the table’s lower position, the pinch bolts holding the steel casing into the diverter are loosened and the suspension cables are re-attached to the top of the diverter.

17. Then, another drill rod is threaded into the top head from the carousel, and Steps 3 through 7 above are repeated.

18. The new length of steel casing is butt-welded onto the top of the length of steel casing that is held in the special drill table, and the casing-as-you-drill through the caving overburden is continued. (see photo H)

19. When the top of the bedrock is encountered, the down-the-hole hammer, air-rotary drilling continues to the design depth.

20. For a geothermal heat-exchanger borehole, the pipe loop is installed to the bottom of the borehole.

21. The pipe loop is then grouted into the un-cased portion of the borehole and the grout is pumped (through a tremie pipe of course) until the bottom length of casing is full of grout.

22. The steel casing is removed using the reverse of the installation process listed above and is cut off into approximately 20-foot lengths. As each length of steel casing is removed, the tremie line is re-connected to the grouter and the next length of casing is filled with grout. The grout fills the entire borehole around the 2 loop pipes as the casing is withdrawn.

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