

Technical Brief No.43: Simple drilling methods

In many developing countries, water is obtained from handpumps installed above shallow (less than 60m) boreholes. It can be expensive to drill the borehole, however, if traditional machine-drilling rigs are used. This Technical Brief outlines simple, low-cost drilling methods which may be used in various situations. Each can be used and maintained easily.

Drilling constraints

Whatever drilling method is used, there are several considerations which must be taken into account:

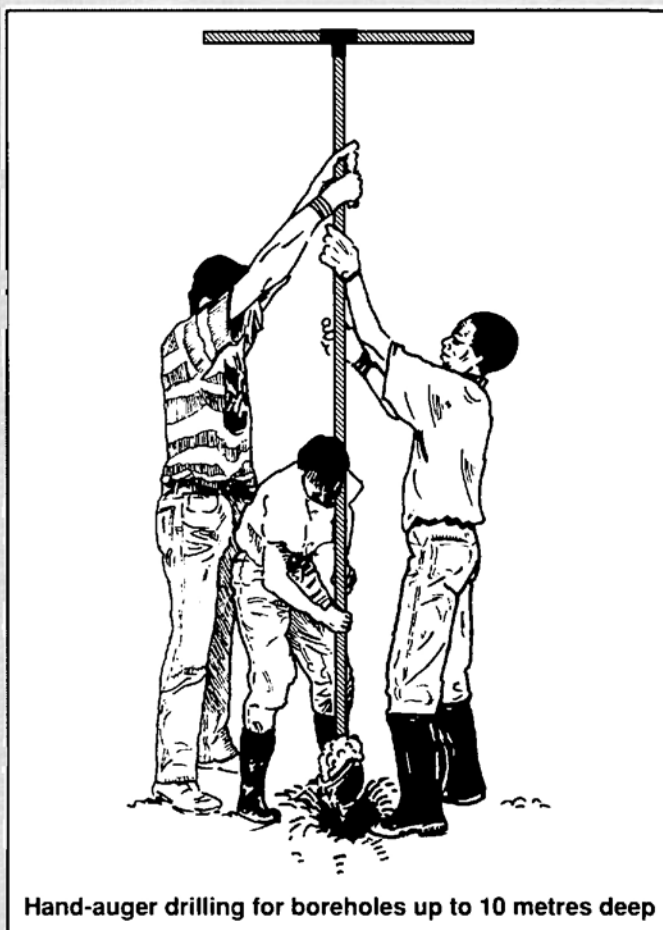
- The amount of energy required to drill is governed by the rock type. Unconsolidated formations such as sand, silt or clay are weak and much easier to drill than consolidated rocks such as granite, basalt or slate which are hard, strong and dense.
- For hard rocks, cutting tools will need cooling and lubrication.
- Rock cuttings and debris must be removed.
- Unconsolidated formations will require support to prevent the hole from collapse.

Drilling methods

The following low-cost, appropriate drilling methods are described and illustrated on the following pages:

- Percussion drilling
- Hand-auger drilling
- Jetting
- Sludging
- Rotary-percussion drilling
- Rotary drilling with flush

The table below may be used as a guide in the selection of the most appropriate drilling method.



Hand-auger drilling for boreholes up to 10 metres deep

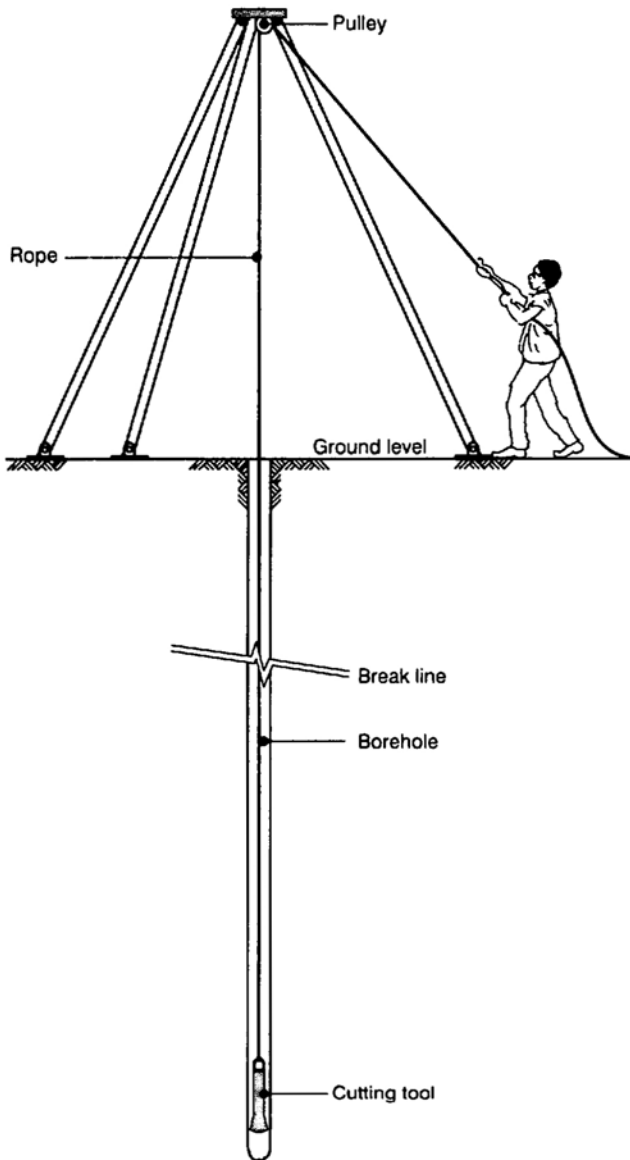
Table 1. Drilling-method selection		Percussion drilling	Hand-auger drilling	Jetting	Sludging	Rotary percussion drilling	Rotary drilling with flush
Gravel	Unconsolidated formations	✓?	✗	✗	✗	✓?	✗
Sand		✓?	✓	✓	✓	✓?	✓
Silt		✓?	✓	✓	✓	✓?	✓
Clay		✓ slow	✓	?	✓	✓ slow	✓
Sand with pebbles or boulders		✓?	✗	✗	✗	✓?	✗
Shale	Low to medium-strength formations	✓	✗	✗	✗	✓ slow	✓
Sandstone		✓	✗	✗	✗	✓	✓
Limestone	Medium to high-strength formations	✓ slow	✗	✗	✗	✓	✓ slow
Igneous (granite, basalt)		✓ slow	✗	✗	✗	✓	✗
Metamorphic (slate, gneiss)		✓ v slow	✗	✗	✗	✓	✗
Rock with fractures or voids		✓	✗	✗	✗	✓	✓!
Above water-table		✓	✓	?	✗	✓	✓
Below water-table		✓	?	✓	✓	✓	✓

✓ = Suitable drilling method ✓? = Danger of hole collapsing ✓! = Flush must be maintained to continue drilling ? = Possible problems ✗ = Inappropriate method of drilling

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Percussion drilling

Method: The lifting and dropping of a heavy (50kg+) cutting tool will chip and excavate material from a hole. This drilling method has been used in China for over 3000 years. The tool can be fixed to rigid drill-rods, or to a rope or cable. With a mechanical winch, depths of hundreds of metres can be reached.



Advantages of percussion drilling:

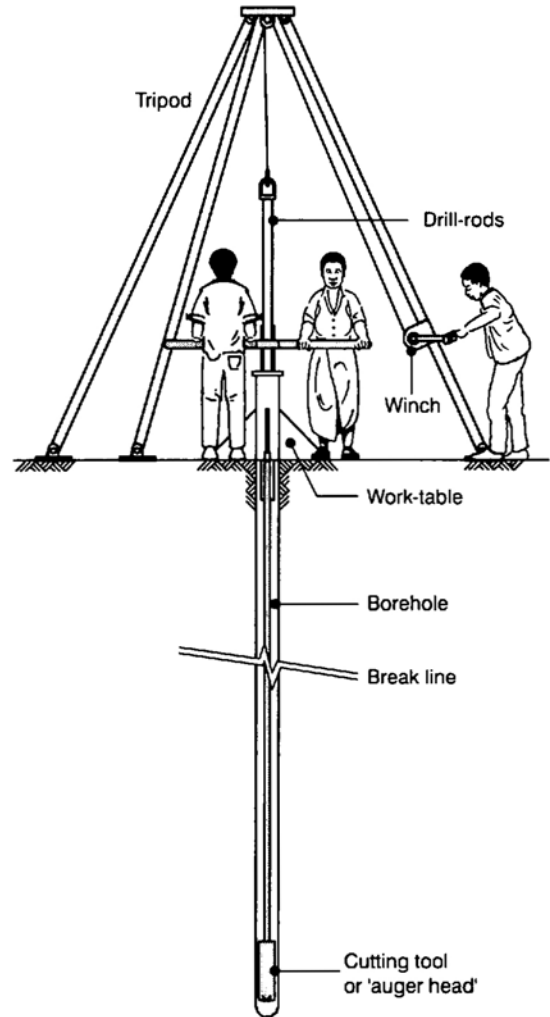
- Simple to operate and maintain.
- Suitable for a wide variety of rocks.
- Operation is possible above and below the water-table.
- It is possible to drill to considerable depths.

Disadvantages of percussion drilling:

- Slow, compared with other methods.
- Equipment can be heavy.
- Problems can occur with unstable rock formations.
- Water is needed for dry holes to help remove cuttings.

Hand-auger drilling

Method: The cutting tool (known as the auger head) is rotated to cut into the ground, and then withdrawn to remove excavated material. The procedure is repeated until the required depth is reached. Note: This method is only suitable for unconsolidated deposits.



Advantages of hand-auger drilling:

- Inexpensive.
- Simple to operate and maintain.

Disadvantages of hand-auger drilling:

- Slow, compared with other methods.
- Equipment can be heavy.
- Problems can occur with unstable rock formations.
- Water is needed for dry holes.

Useful contacts:

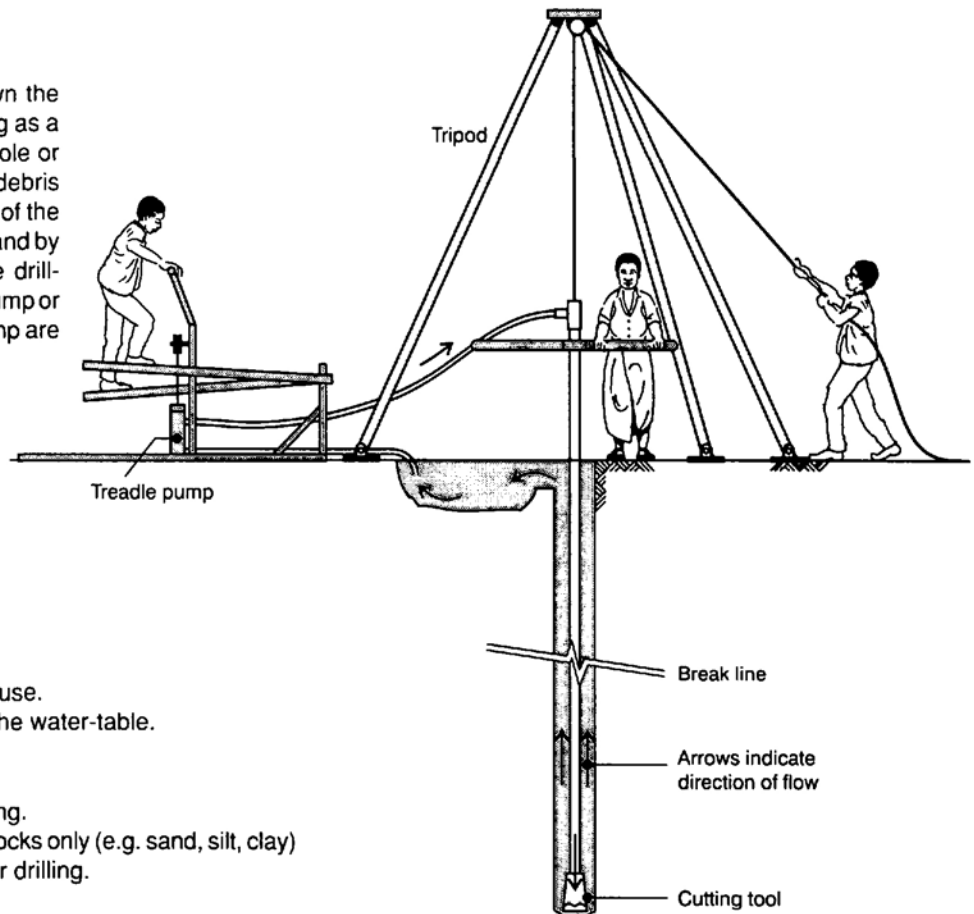
Van Reekum Materials b.v., 115 Kanaal Noord, PO Box 98, AB Apeldoorn, The Netherlands.

Tel: +31 55 335466 Fax: +31 55 313335

V & W Engineering Ltd. (Vonder Rig), PO Box 131, Harare, Zimbabwe. Tel: +263 4 64365/63417 Fax: +263 4 64365

Jetting

Method: Water is pumped down the centre of the drill-rods, emerging as a jet. It then returns up the borehole or drill-pipe bringing cuttings and debris with it. The washing and cutting of the formation is helped by rotation, and by the up-and-down motion of the drill-string. A foot-powered treadle pump or a small internal-combustion pump are equally suitable.



Advantages of jetting:

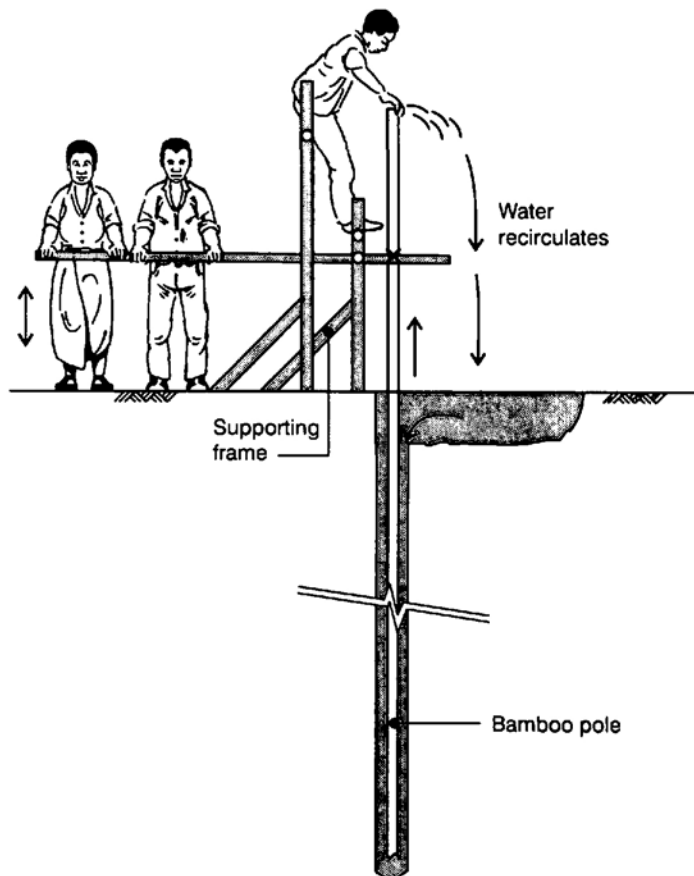
- The equipment is simple to use.
- Possible above and below the water-table.

Disadvantages of jetting:

- Water is required for pumping.
- Suitable for unconsolidated rocks only (e.g. sand, silt, clay)
- Boulders can prevent further drilling.

Sludging (reverse jetting)

Method: This method has been developed and used extensively in Bangladesh. A hollow pipe of bamboo or steel is moved up and down in the borehole while a one-way valve – your hand can be used to improvise successfully – provides a pumping action. Water flows down the borehole annulus (ring) and back up the drill-pipe, bringing debris with it. A small reservoir is needed at the top of the borehole for recirculation. Simple teeth at the bottom of the drill-pipe, preferably made of metal, help cutting efficiency.



Advantages of sludging:

- The equipment can be made from local, low-cost materials, and is simple to use.

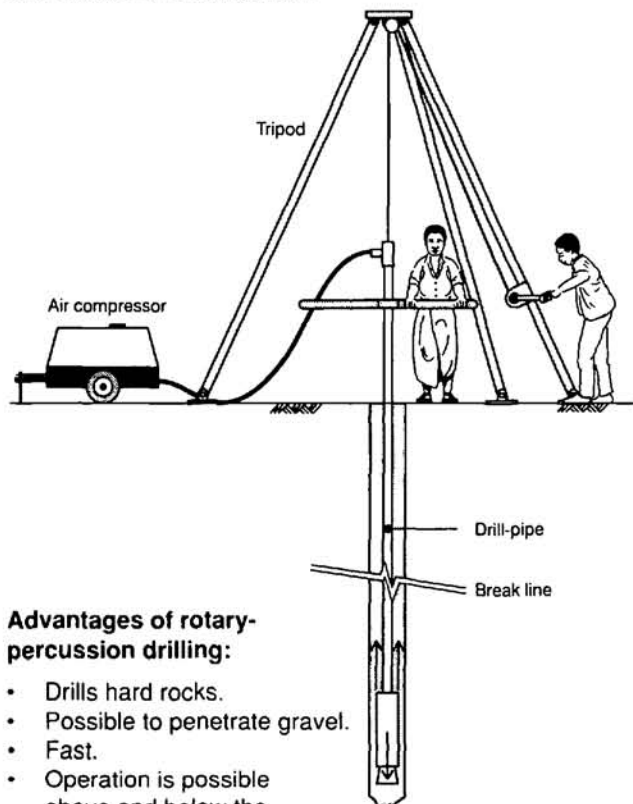
Disadvantages of sludging:

- Water is required for pumping.
- Suitable for unconsolidated rocks only.
- Boulders can prevent further drilling.

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Rotary-percussion drilling

Method: In very hard rocks, such as granite, the only way to drill a hole is to pulverize the rock, using a rapid-action pneumatic hammer, often known as a 'down-the-hole hammer' (DTH). Compressed air is needed to drive this tool. The air also flushes the cuttings and dust from the borehole. Rotation of 10-30 rpm ensures that the borehole is straight, and circular in cross-section.



Advantages of rotary-percussion drilling:

- Drills hard rocks.
- Possible to penetrate gravel.
- Fast.
- Operation is possible above and below the water-table.

Disadvantages of rotary-percussion drilling:

- Higher tool cost than other tools illustrated here.
- Air compressor required.
- Requires experience to operate and maintain.

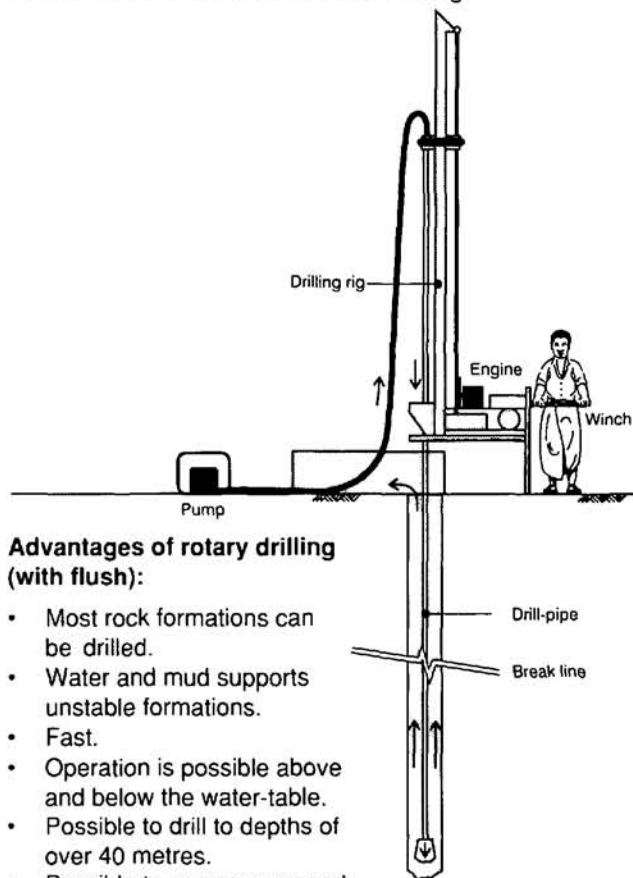
Useful contacts:

Consallen Group Sales Ltd., 23 Oakwood Hill Industrial Estate, Loughton, Essex, IG10 3TZ, UK. Tel/Fax: +44 81 508 5006

Eureka UK Ltd., 11 The Quadrant, Hassocks, West Sussex BN6 8BP, UK. Tel: +44 273 846333 Fax: +44 273 846332

Rotary drilling with flush

Method: A drill-pipe and bit are rotated to cut the rock. Air, water, or drilling mud is pumped down the drill-pipe to flush out the debris. The velocity of the flush in the borehole annulus must be sufficient to lift the cuttings.



Advantages of rotary drilling (with flush):

- Most rock formations can be drilled.
- Water and mud supports unstable formations.
- Fast.
- Operation is possible above and below the water-table.
- Possible to drill to depths of over 40 metres.
- Possible to use compressed-air flush.

Disadvantages of rotary drilling (with flush):

- Requires capital expenditure in equipment.
- Water is required for pumping.
- There can be problems with boulders.
- Rig requires careful operation and maintenance.

Useful contacts:

Eureka UK Ltd., 11 The Quadrant, Hassocks, West Sussex BN6 8BP, UK. Tel: +44 273 846333 Fax: +44 273 846332

PAT Co. Ltd., 1016 Taskin Road, Thonburi, Bangkok, Thailand. Tel: +66 2 476 1845 Fax: +66 2 476 5316

Further information

Allen, D.V., *Low-Cost Hand Drilling*, Consallen Group Sales Ltd., Loughton, UK, 1993.

Ball, P., *Bringing Water to the People: Technical brochure*, Eureka UK Ltd., Hassocks, UK, 1994.

Mutwalib, W., *Evaluation of the Muyembe Rural Water Supply*, Loughborough University of Technology, Loughborough, UK, 1994.

Prepared for IT Publications by Bob Elson and Rod Shaw

Water, Engineering and Development Centre (WEDC),

Loughborough University of Technology, Leicestershire, LE11 3TU, UK. Fax: +44 (0) 1509 211079



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