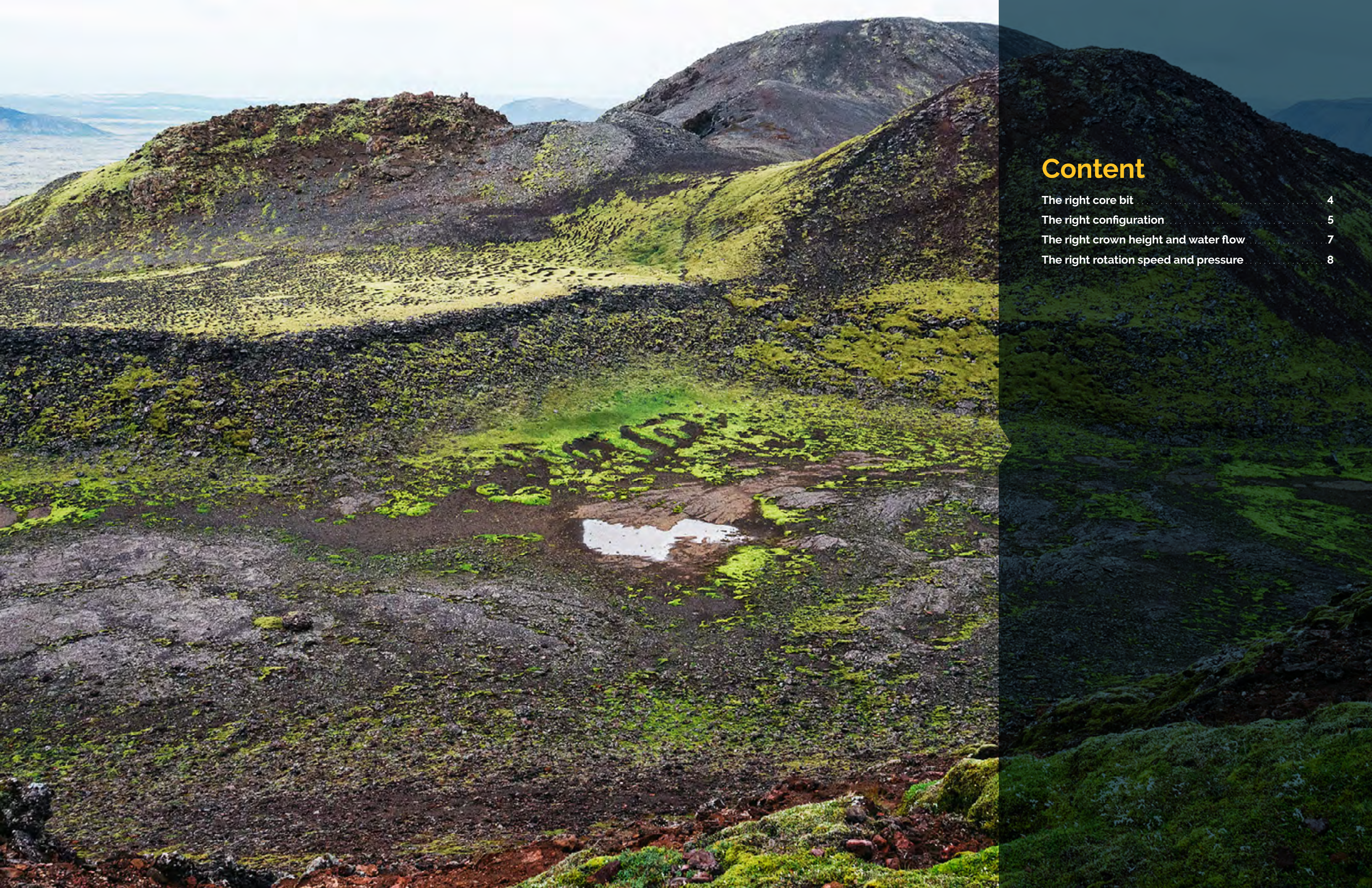


Improving your rate of penetration

Essential diamond drillers' guide





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“Reviewing bit performance is important - it may provide critical information to help you find the right bit and to improve productivity.”

In the drilling industry, the rate of penetration (ROP) is the speed at which a drill bit advances through the rock under it to deepen the borehole. Also known as penetration rate or drill rate, it is normally measured in inches per minute or meters per hour, but sometimes it is expressed in minutes per foot.

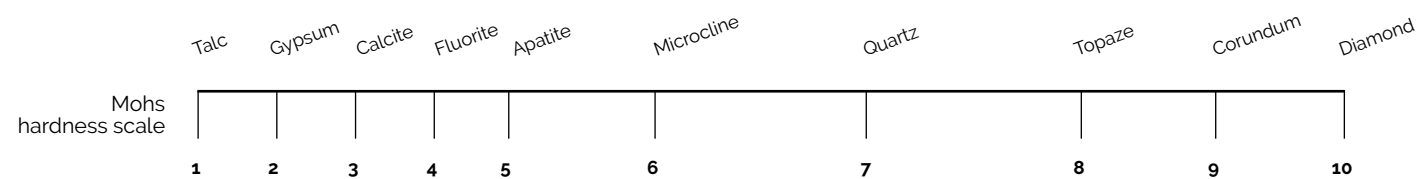
This measurement is often used as a benchmark against which to measure changes in drilling parameters or processes. For example, if you were to change your core matrix, you would look at your penetration rate with the old bit and compare it with the rate you achieve using a new bit. In the same way, if you were to change your rotation speed or bit pressure, you would want to see how it affects your ROP.

Improving penetration rates has a direct impact on profitability as it **will increase productivity and lead to recuperating more core**. How to achieve better penetration is a challenge for many drillers but there are several factors that must be considered.

The right core bit

First and foremost, you need to choose the right core bit for the type of ground you will be drilling. You will need to determine the hardness of the rock you will be drilling according to Mohs scale. This can be done easily using a scratch test.

To help you narrow down your choices, you should then refer to a matrix selection chart which will suggest bits that have been developed specifically for different types of rock hardness.



Other options could include core bits that are self-sharpening, such as the **T-Xtreme 9-11** or the **Hero 11 Abrasive**. This kind of core bit has a softer matrix that has been developed to provide excellent penetration rates by allowing the diamonds to come into contact with the ground very quickly. Penetration rate is optimized with regular sharpening with a high pressure feed.



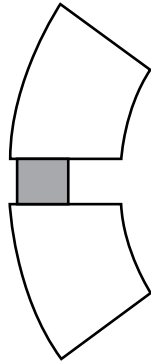
The right configuration

Once you have an idea of the matrix you need, you will also need to consider the type of waterway configuration. You will need to look at the pattern, the number of waterways as well as the width between the waterways as all of these will play a role.

Configurations are available with different waterway widths and matrix heights. Terrain can be either fractured or competent and each will need a different kind of drill bit. For example, a bit with a deep lateral discharge waterway configuration is ideal for fractured rock. It is designed to allow better water flow to the bit with reduced risk of eroding the core.

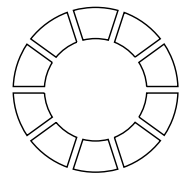
Make sure to refer to the Fundamental Guide to Core Bit Configurations for more in-depth information and advice.

Deep lateral discharge



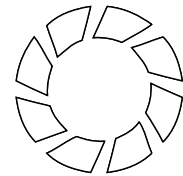
- Features a deeper waterway design to increase the space for water and mud to flow to the bit
- Has waterways that limit water and pressure on the core sample
- Is ideal for soft broken ground
- Is the preferred choice when sampling in overburden

Standard



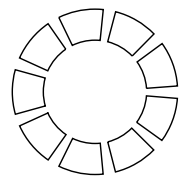
- Provides great fluid circulation from the inside to the outside diameters
- Is available with wider and/or larger waterways

Cyclone



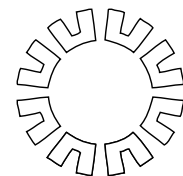
- Provides great fluid circulation from the inside to the outside diameters
- Is available with wider and/or larger waterways

Pie shaped



- Has pie-shaped openings to ensure greater ejection of rock cuttings that may block waterways
- Is recommended for higher rotation speeds

Turbo pie shaped (TPS)



- Is a freer cutting bit
- Provides the same optimal flushing performance
- In some cases, can reach higher penetration rates when compared with the non-turbo.
- Is available with wider and/or larger waterway configurations

Other waterway configurations available

The right crown height

A core bit with a higher crown impregnated with diamonds, such as the **Vulcan**, may also help improve penetration rates. For example, if you are averaging 200 meters with a 13 mm crown, but your borehole is 250 meters, a Vulcan bit can allow you to complete the hole without changing

the bit. However, care must be taken to choose a Vulcan with a matrix that is suitable for the type of ground you will be drilling. As a Vulcan typically lasts up to 33% longer than a normal core bit, it should be used in ground that is not variable.

For example, let's say you have chosen a Vulcan with a matrix for medium ground. You are drilling and after 100 meters the ground changes to a very hard ground, the Vulcan will not be suitable

and you risk prematurely wearing the Vulcan or burning it. While it is a tool that can offer great results, you must be certain of the hardness and the type of ground.



Some ground is more variable. It may be soft for the first 100 feet and then become harder or fractured. When dealing with variable ground there are many products on the market that provide the versatility needed to perform well in varying conditions, such as the **Hero series**.

The right water flow

Make sure there is proper and sufficient water flow to the bit. A check that your rods don't leak is suggested. The use of drilling additives, such as **DD-2000**, can help with

flushing cuttings so that coring is faster and wear on the drill bit is reduced. **Torqueless** is an excellent product that reduces torque, protects against wear and extends bit life.



The right rotation speed and pressure

Rotation speed should be chosen carefully based on the diameter of the system you are using. If you are penetrating the rock quickly, it is possible to rotate the rods faster which will enhance ROP. Or if you are having difficulty penetrating the rock, you can reduce RPM and help increase ROP.

(See the chart below).

Operating parameters

Size	Normal recommended bit load range	Normal recommended RPM	Normal recommended fluid circulation rates	Estimated penetration rates	
				150 rev/in drilled 60 rev/cm drilled	250 rev/in drilled 100 rev/cm drilled
AWL	2,000 to 4,000 lb 8.9 to 18 kN	800 to 2,000 RPM	1.5 to 3.5 US Gal/ min 5.7 to 13 Liter/min	5.3 to 13.2 in/min 13 to 34 cm/min	3.2 to 7.9 in/min 8.1 to 20 cm/min
AWL THIN KERF	2,000 to 3,500 lb 7.9 to 16 kN				
BWL	3,000 to 5,500 lb 13 to 24 kN	650 to 1,600 RPM	2 to 5.5 US Gal/ min 7.6 to 21 Liter/min	4.2 to 10.6 in/min 11 to 27 cm/min	2.5 to 6.4 in/min 6.4 to 16 cm/min
BWL THIN KERF	2,500 to 5,000 lb 11 to 21 kN				
NWL	4,500 to 8,500 lb 20 to 38 kN	500 to 1,250 RPM	3.5 to 9 US Gal/ min 13 to 34 Liter/min	3.4 to 8.4 in/min 8.6 to 21 cm/min	2.0 to 5.0 in/min 5.1 to 13 cm/min
NWL THIN KERF	4,000 to 8,000 lb 19 to 35 kN				
HWL	6,500 to 13,000 lb 29 to 58 kN	400 to 1,000 RPM	5 to 14 US Gal/min 19 to 53 Liter/min	2.6 to 6.6 in/min 6.6 to 17 cm/min	1.6 to 4.0 in/min 4.1 to 10 cm/min
PWL	10,000 to 19,000 lb 44 to 84 kN	300 to 800 RPM	7.5 to 20 US Gal/ min 28 to 76 Liter/min	2.1 to 5.2 in/min 5.3 to 13 cm/min	1.2 to 3.1 in/min 3.0 to 7.9 cm/min

Bit pressure, or the force applied on the bit, plus the weight of the rods that are being used must be as low as possible while maintaining a good penetration rate. You should put only as much pressure on the bit as needed to advance. To achieve a good penetration rate you must aim for

the ideal combination of rotation speed and bit pressure. This relationship will change as you add each rod. As you advance deeper into the hole, you will add rods and your rod weight will increase. It is likely that you will need to reduce your feed pressure. At some point if you are using many rods, your rod weight alone can become more than the pressure you have been exerting, meaning that you may

need to hold back pressure. This needs to be managed carefully and many experienced drillers "feel" when the pressure needs to change or be held back.

Drillers who feel uncertain can always request technical support or an onsite visit. The Epiroc technical team is dedicated to improving drillers' performance, and an onsite visit is an excellent opportunity to address issues and answer questions.



