

## Some characteristics of drilling techniques



*Figure 1. Example of rock cores. They are more or less cylindrical, depending on the alterability of the rock, but also according to the coring technique. For example, for very deformable materials, a double core barrel is used, of which only the outer part rotates with the drill string, while the central part remains free of any rotation. [Source: © F.H. Cornet]*

A drilling operation can have several objectives. This may involve taking a rock sample at a specific location to bring it to the surface; this is called **core drilling** (Figure 1).

These **exploration wells** can have various depths. The deepest ever reached a depth of 12,345 m, near the island of Sakhalin in eastern Russia. In addition to collecting rock samples, drill holes allow a number of geophysical measurements to be carried out *in situ*. The description of continuous variations of a physical property along a well is called a **log**. For example, **sonic logging** is used to describe variations along the borehole in the propagation velocity of so-called sound waves, i.e. waves emitted in a frequency range covering the sensitivity range of our hearing (20 Hz-10 000 Hz).



*Figure 2. Examples of drilling tools. On the left is the corer used to produce the cores in Figure 6. On the right are two examples of wheel drills. [Source: © F.H. Cornet]*

But most often the purpose of drilling is to produce fluids in place in the rock at a certain depth, whether it is drinking water (generally less than 100 m deep), hydrocarbons (from 2000 to 7000 m), or geothermal fluids (in the 150 - 5000 m range). These holes are drilled using a **destructive method**, i.e. the rock is crushed in place by a drill head (Figure 2), or **drill bit**, pushed by a drill **string** (Figure 3).

The rock debris (**cuttings**) is brought to the surface by a circulation of mud injected by the drill string. The viscosity of this slurry is adjusted for optimum cutting removal and its density is adjusted to ensure the stability of the borehole during drilling.



*Figure 3. Example of a small drilling rig to reach a depth of 800 m. The drill pipes are placed here in front of the device. For greater depths, the rods are held vertically next to the drilling rig and are handled automatically. [Source: © F.H. Cornet]*

For shallow wells drilled for drinking water production, the drilling technique is often simpler and uses a **down the hole hammer**. This technique is equivalent to that of the jackhammer, the compressed air being brought to the bottom by the **drill string**. Note that the air pressure must be sufficient to lift the weight of the water column that fills the borehole. For example, blowers capable of reaching pressures of around 100 bar must be used for depths exceeding 800 m. In practice, this technique is mainly used for boreholes not exceeding 200 m in depth.

When the borehole reaches a certain depth, it must be tubed regularly to balance the stresses supported by the rock at the borehole wall. This operation is called the casing of the well, and the steel pipe left in place is called the casing. During its manufacture, the **casing** may have a certain number of slots to allow the production of the required fluid. But more often than not, the **casing is cemented** to prevent any fluid from rising along the borehole outside the **casing**. The production of fluid is then ensured, once the **casing** has been placed in a watertight manner, thanks to **perforations** made using various techniques that vary according to the operators.

With the traditional drilling technique, the drill **string** allows on the one hand to inject the mud used to extract rock debris, and on the other hand to rotate the drilling tool on its axis. This rotation operation involves significant friction throughout the drilling process and therefore causes rapid wear of the drill **string** for deep drilling. To overcome these difficulties, drill heads that can rotate on themselves thanks to the injected mud pressure, without rotating the **drill string**, have gradually been developed. These turbines have also provided the opportunity to better control the drilling direction. These techniques now allow **horizontal drilling** operations over **distances of up to ten kilometres**.

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