Methods of Drilling
Drilling means to make a hole in the ground or rocks for the purpose of getting information about interior of the earth.

There are a variety of drill mechanisms which can be used to drill a borehole in the ground.

Each has its advantages and disadvantages,

• in terms of the depth to which it can drill,
• the type of sample returned,
• the costs involved and
• penetration rates achieved
PURPOSE OF DRILLING

I. for the purpose of blasting
II. for prospecting and exploration
III. for the purpose of ground water
IV. to define ore body at depth
V. for estimation of ore reserve (to estimate the tonnage and grade of a discovered mineral deposits)
VI. to access ground stability (geotechnical)
Drill hole may be of three types

1. **Primary holes:**
   for the purpose of inspection of mineral deposits.

2. **Exploratory holes:**
   drilled for the purpose of exploration of water, oil and gas.

3. **Technical holes:** drilled for a specific purpose for generating technical data.
Classification of Drilling

A. On the basis of material obtained from the hole, there are two main types.

1. **CORE DRILLING**: where by means of drilling core can be obtained
2. **NON CORE DRILLING**: where only rock cuttings along with slurry can be obtained.

B. On the basis of presence of water, there are two main types.

1. **DRY DRILLING**: in this type of drilling, water is not involved
2. **WET DRILLING**: in this type of drilling, water is used for the drilling operation.
C. On the basis of **principal involved** in the operation, drilling may be classified as

1. **PERCUSSION**: (Pneumatic)

   Types of percussion drillings are;
   
   a) Down The Hole drills (DTH) OR Rotary Air Blast drilling (RAB)
   
   a) Top hammer drilling
   
   b) Reverse circulation drilling

2. **ROTARY DRILL**

   a). Auger drill
   
   b). Calyx drill
   
   c). Rotary drill (using rock roller bit, tricone bits)
   
   d). Diamond drill (using diamond bit, T.C. bits)
1. **PERCUSSION: (Pneumatic)**

- In percussion drilling, a hammer unit driven by compressed air imparts a series of short rapid blow to the drill rod or bit and at the same time imparts a rotary motion. This type of drilling involves the rotary and hammering action both for cutting rocks and making drill holes.

- It is cheap, economical and easy to operate and is suitable for exploration to a depth up to **100m in unconsolidated** material like placer and gravel deposits.

- Only **vertical hole** can be drilled by this method.
Percussion Drilling (Cont’d)

(a). Down The Hole drills (DTH) OR Rotary Air Blast drilling (RAB)

- The hammer unit is lowered into the hole attached to the lower end of the drill rods to operate the non coring tungsten carbide tripped drill bit.

- The DTH drill uses a pneumatic reciprocating piston-driven “hammer” to energetically drive a heavy drill bit into the rock.

- Holes with diameter up to 20 cm and penetration depth of up to 200 m are possible, but depth of 100-150 m are more usual.
Percussion Drilling (Cont’d)

- Drill cuttings are flushed to the surface by compressed air.
- As the cuttings come to surface they can be related to depth of the hole.
- However such direct correlation is not always reliable as holes may not be cased and material may fall from higher levels.

(b). Top Hammer Drill

- As the name suggests the hammer unit is driven by compressed air at the top of the drill stem and energy to the non coring drill is imparted through the drill rods.
- These are usually lighter unit than the DTH hammer drills. The are used for holes up to 10 cm diameter and depths up to 100 m, but more usually 20 m.
Percussion Drilling (Cont’d)

- This method uses only light air compressors and this restricts drilling depths to at the most only a few meters below a water table. OR drilling ends as soon as it comes into contact with the water table because the hydrostatic pressure is more than the air pressure.

- It becomes impossible for the pressurized air to blow the heavy wet rock sludge to the surface.

- Samples cannot be recovered after the water table is reached.

- RAB drilling in the mine is mostly done for blast holes.

- Usually they are mounted on either light trucks or tractors.
SUMMARY (DTH/RAB)

- Cheapest
- Least penetrative (~100-150m)
- Uses compressed air to break the ground
- Air pumped down through drill rod
- Cuttings blown up hole between rod and hole wall
- Single barrel technique
Advantages of RAB drilling

• Cheap
• Fast
• Large sample volume

Disadvantages of RAB drilling

• No fresh rock samples
• Limited depth
• No structural data
• Contamination
(c). Reverse circulation drilling

- It can be used in unconsolidated sediments such as alluvial deposits or for drilling rocks.

- Both air and water can be used as the drill flushing medium and both cuttings and core can be recovered.

- The technique employs a double wall string of drill rods with either a compressed air driven percussion hammer or a rotating tungsten carbide coring bit at the cutting end of the string.

- The medium is supplied to the cutting bit between the twin walled drill rods.
Percussion Drilling (Cont’d)

- This type of drilling involves the use of high pressure compressors, percussion hammers that recover samples even after the water table.

- The end of the hammer is a tungsten carbide bit that breaks the rock with both percussion and rotary movement.

- The air pressure of a RC rig can be increased by the use of a booster. This allows for deeper drilling.

- This type of drilling is faster and cheaper than diamond drilling.
Percussion Drilling (Cont’d)

Schematic presentation of RC drilling rig
Summary RC drill

- Moderately priced
- Good penetration (to ~350m)
- Samples fresh rock
- Dual barrel technique
- High pressure fluid forced down outer pipe and returns chips to surface up inner pipe
Advantages of RC drilling:

• Relatively cheap
• Quick
• Large sample
• Uncontaminated

Disadvantages of RC drilling:

• Limited access
• No structural data
• Sample contamination below water table
2. **ROTARY DRILL**

In this type of drilling, Drilling tools are rotated by a prime mover and at the same time certain amount of pressure is applied.

Types of rotary drillings;

(a). Auger drill
(b). Calyx drill
(c). Rotary drill (using rock roller bit, tricone bits)
(d). Diamond drill (using diamond bit, T.C. bits)

Among the type of drill, diamond drill is most commonly employed.
a) Auger drill Auger drill

- Augers are hand held or truck mounted drills.
- Auger drilling is done with a helical screw which is driven into the ground with rotation; the earth is lifted up the borehole by the blade of the screw.
- Solid flight augers/bucket augers are used in harder ground construction drilling.
- In some cases, mine shafts are dug with auger drills.
- Small augers can be mounted on the back of a utility truck, with large augers used for sinking piles for bridge foundations.
Hand auger (bucket auger)

RODS
Short lengths screw together

BARREL
Cuttings recovered by pulling from ground

Screw auger (power driven)

Auger flight

Bit
Auger Drilling for beach sand exploration
Rotary Drilling (Cont’d)

- Auger drilling is often used for site investigation, environmental and geotechnical drilling and sampling, and boreholes for construction purposes.

- The advantages of auger drilling include low operating costs, fast penetration rates in suitable formations and no contamination of samples by fluids.

- Auger drilling is restricted to generally soft unconsolidated material or weak weathered rock.

- Truck mounted rigs capable of reaching depths of up to 60m, but depths of less than 30m are more common.
2. Calyx drill

- A rotary core drill that uses hardened steel shot for cutting rock, which will drill holes from diamond-drill size up to 6 ft (1.8 m) or more in diameter.

- Drilling is slow and expensive, and holes cannot be drilled more than 35 degrees off the vertical, as the shot tends to collect on the lower side of the hole.

- Also called shot drill.
Diamond Drilling

- Diamond drilling can be defined as hard rock rotary drill. Which normally takes a core.

- It can drill hole in any direction and has ability to penetrate in hard and compact rock formation.

- This type of drilling uses a diamond impregnated bit that cuts the rock by rotation with the aid of slimy chemicals in solution such as:
  - DD200, expan-coarse, expan-fine, bentonite and sometimes mapac A and B for holes stability.
The diamonds used are fine to micro-fine industrial grade diamonds. They are set within a matrix of varying hardness, from brass to high-grade steel.

Holes within the bit allow water to be delivered to the cutting face.

Water provides three essential functions; lubrication, cooling, and removal of drill cuttings from the hole.
- Diamond drilling is much slower than reverse circulation (RC) drilling due to the hardness of the ground being drilled.

- Drilling of 1200 to 1800 m is common and at these depths, ground is mainly hard rock.

- Diamond rigs need to drill slowly to lengthen the life of drill bits and rods, which are very expensive.

- Drill sample are recovered as cores sometimes oriented for the purpose of attitude measurement such as dip and dip directions of joints, foliation, lineation, veins
Sampling involves splitting the core into 2 equal halves along the point of curvature of foliations or along orientation lines. One half is submitted to the lab for analysis and the other left in the core yard for future sampling if necessary.

Diamond drilling is usually the last stage of exploration or when the structural behavior of an ore body is to be properly understood.
“Circulation” of the drilling fluid from the mud pit to the mud pump, through the rotary hose, down the drill string, and up the annular space to the surface, where the cuttings are removed and the mud is treated and returned to the mud pit.
Advantages of diamond drilling:

• Maximum geological information
• Uncontaminated
• High quality sampling

Disadvantages of diamond drilling:

• Expensive
• Slow
• Small sample size
• Extensive site preparation and water supply required
Classification of Drilling Bits

- Drag Bit
- Roller Cone Bit (Rock Bit)
- Diamond Bit
Classification of Drilling Bits

Drag Bit
Classification of Drilling Bits

Roller Cone Bits