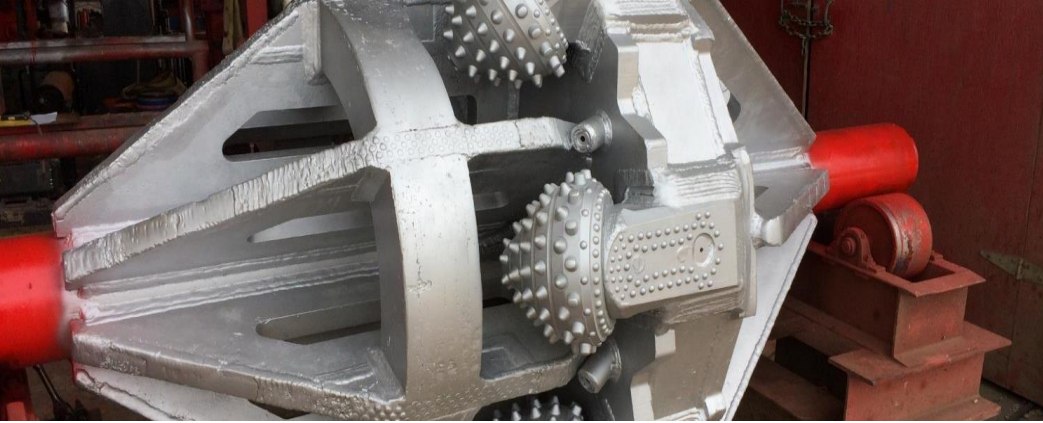


MECHANICS OF TOOLS

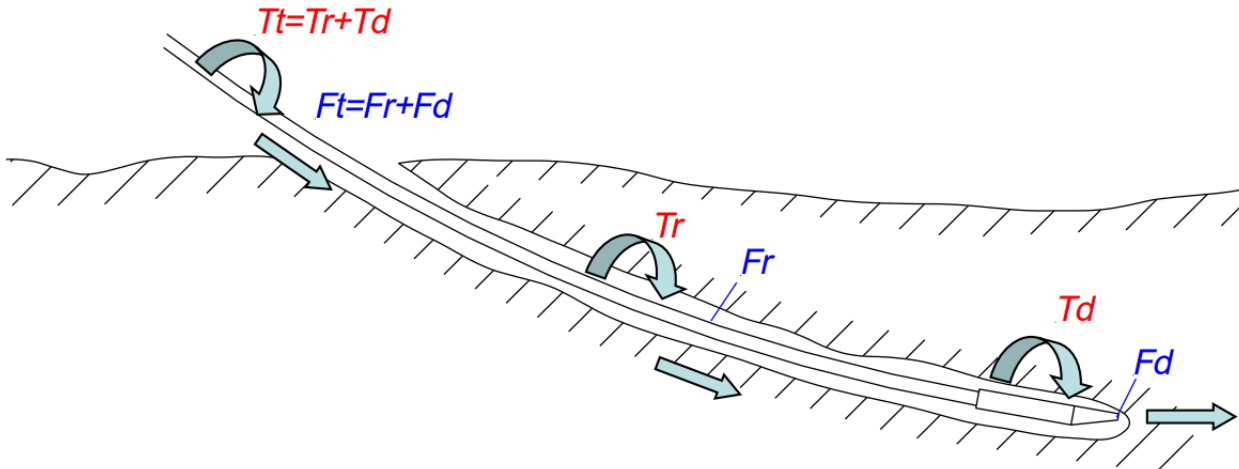
How HDD tools work in differing geological conditions



FORCES DURING PILOT BORE



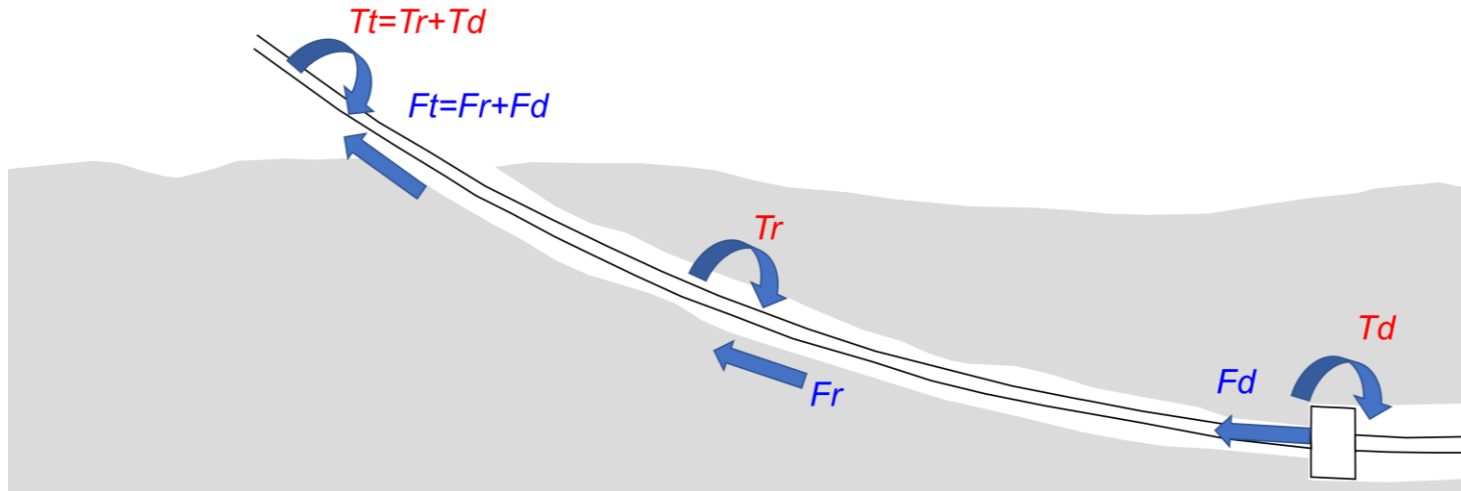
- *Forces during drilling*
- *Forces during steering*
 - *Thrust force and torque for the drillhead to compact/cut the soil (T_d & F_d)*
 - *Thrust force and torque to overcome drag in the hole (T_r & F_r)*



FORCES DURING REAMING



- *Forces during reaming*
 - *Thrust force and torque for the reamer to compact/cut the soil (T_d & F_d)*
 - *Thrust force and torque to overcome drag in the hole (T_r & F_r)*



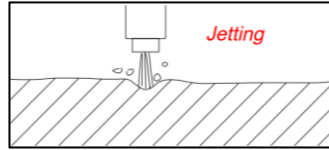
DOWN HOLE TOOLS REQUIREMENTS



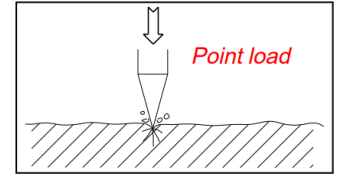
- Torque
- Thrust/Pullback force, WOB (weight on bit)
- Impact energy (hammering)
- Rotational speed
- Nozzle power
- Soil reaction

MAIN DRILLING MECHANISMS IN SOIL AND ROCK

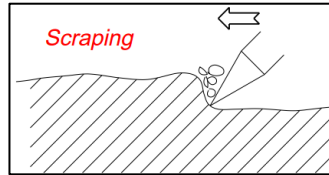
Jetting (hydrodynamic)



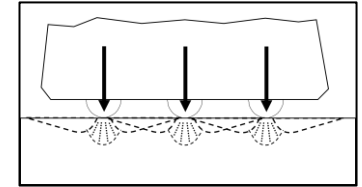
Crushing (compression)



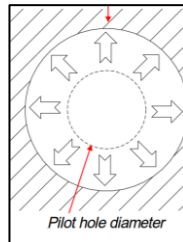
Cutting /Scraping



Crushing (impact)

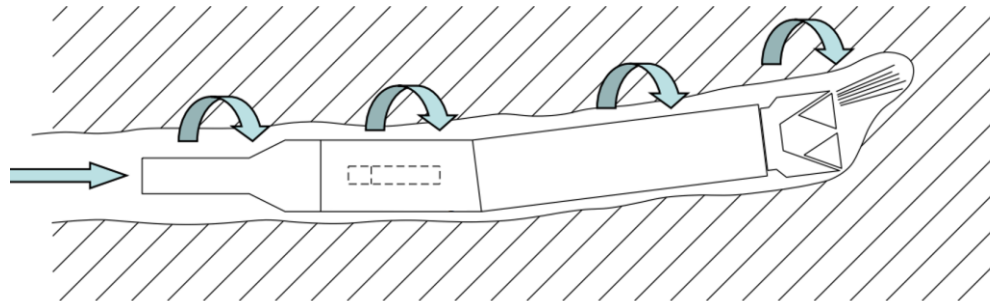
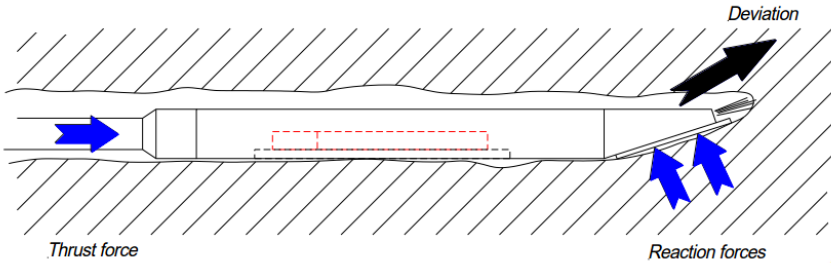
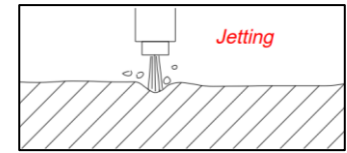


Displacement



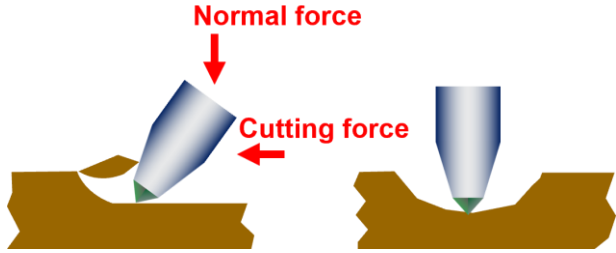
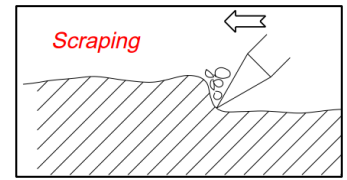
MAIN DRILLING MECHANISMS IN SOIL AND ROCK

Jetting (hydrodynamic)

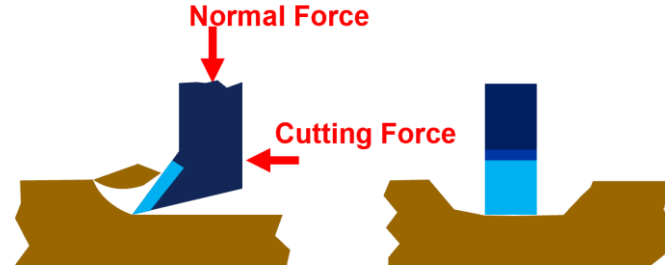


MAIN DRILLING MECHANISMS IN SOIL AND ROCK

Cutting /Scraping



Point attack cutter



Drag Cutter



Soft rock/hard ground
slanted bit



Fly cutter



Mill tooth



Shark Teeth plate bit



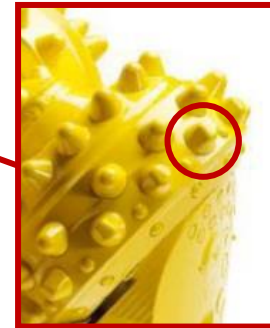
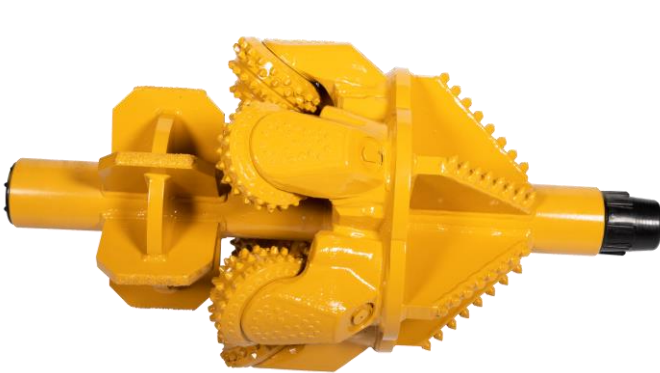
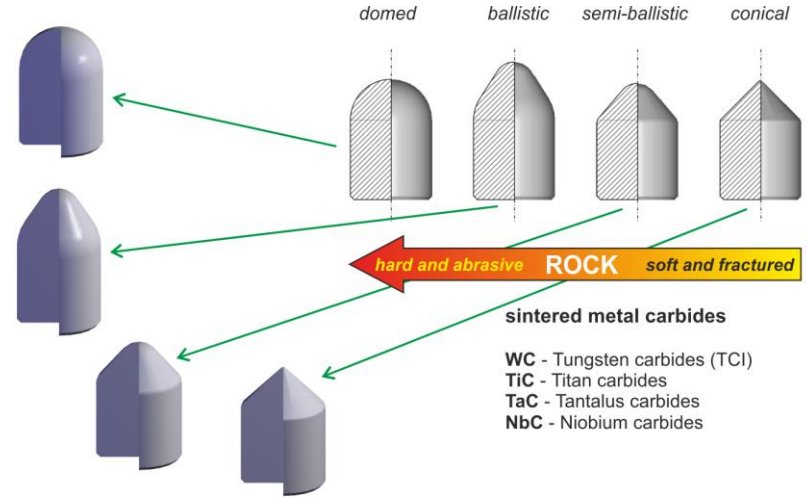
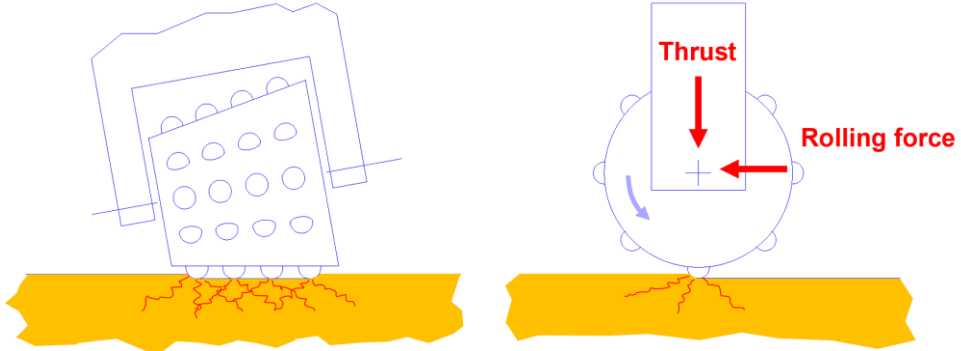
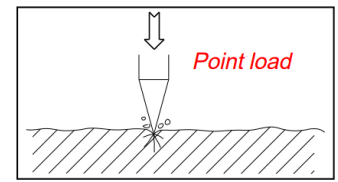
Shark Teeth reamer



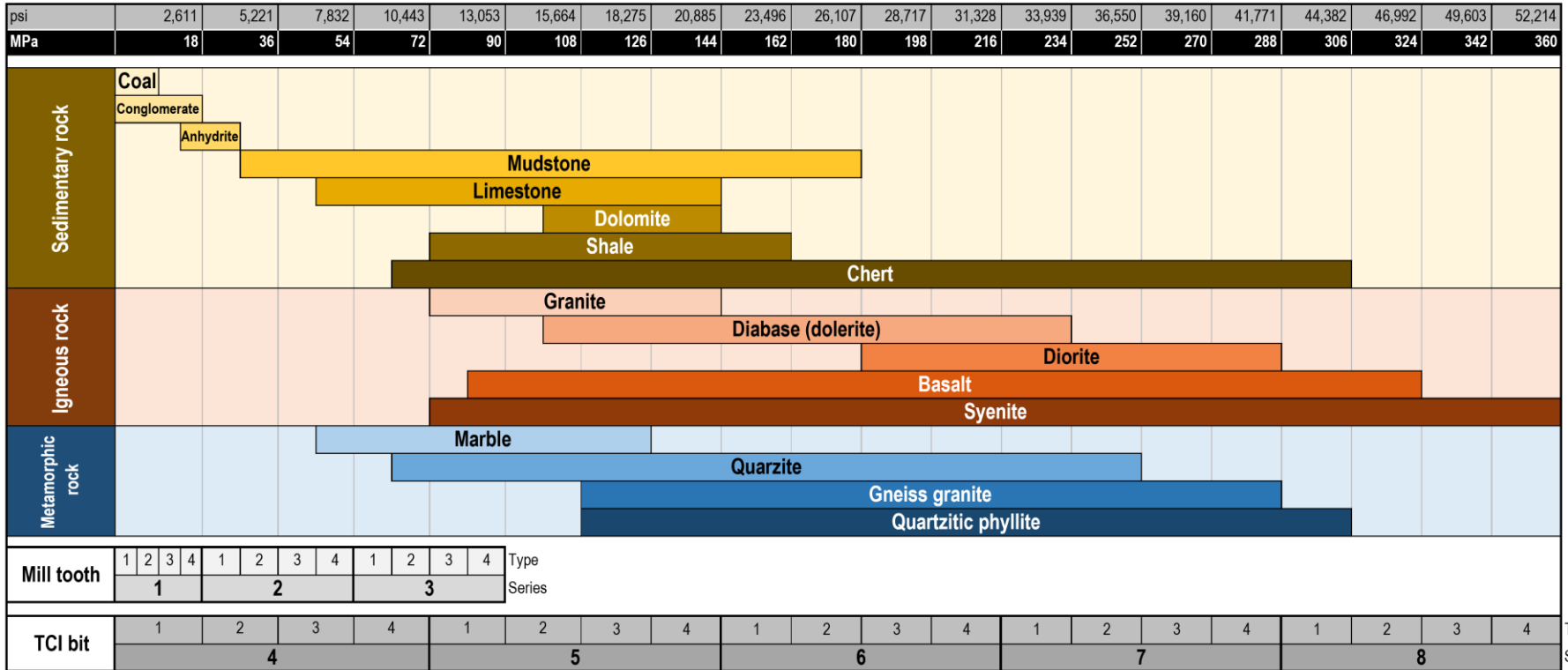
PDC

MAIN DRILLING MECHANISMS IN SOIL AND ROCK

Crushing (compression)

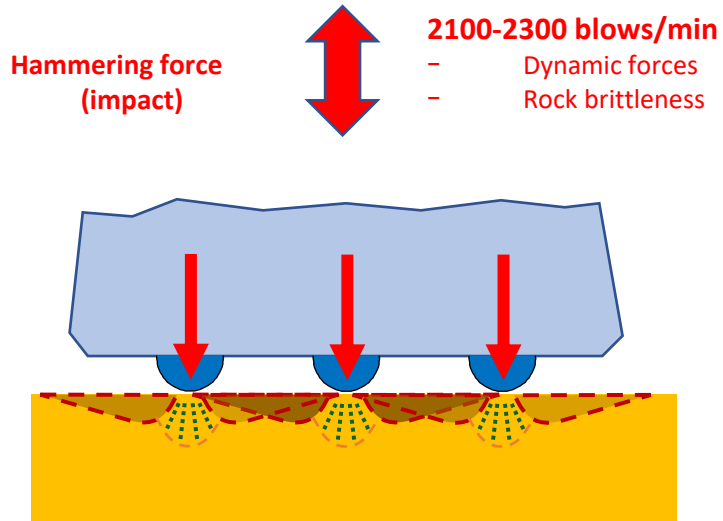


ROCK HARDNESS CHART AND FIRST TWO DIGITS OF THE IADC CODE (TCI AND MILL TOOTH BITS)

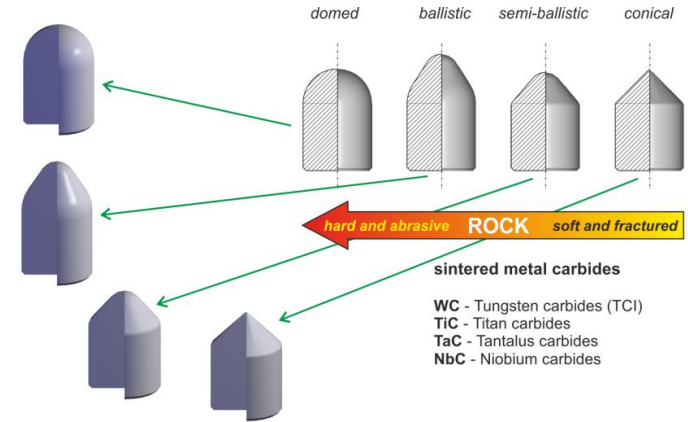
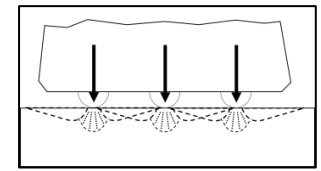


UCS data from Hanssen, 1988; Hoek and Brown, 1980 and Hoek et al., 1992

MAIN DRILLING MECHANISMS IN SOIL AND ROCK

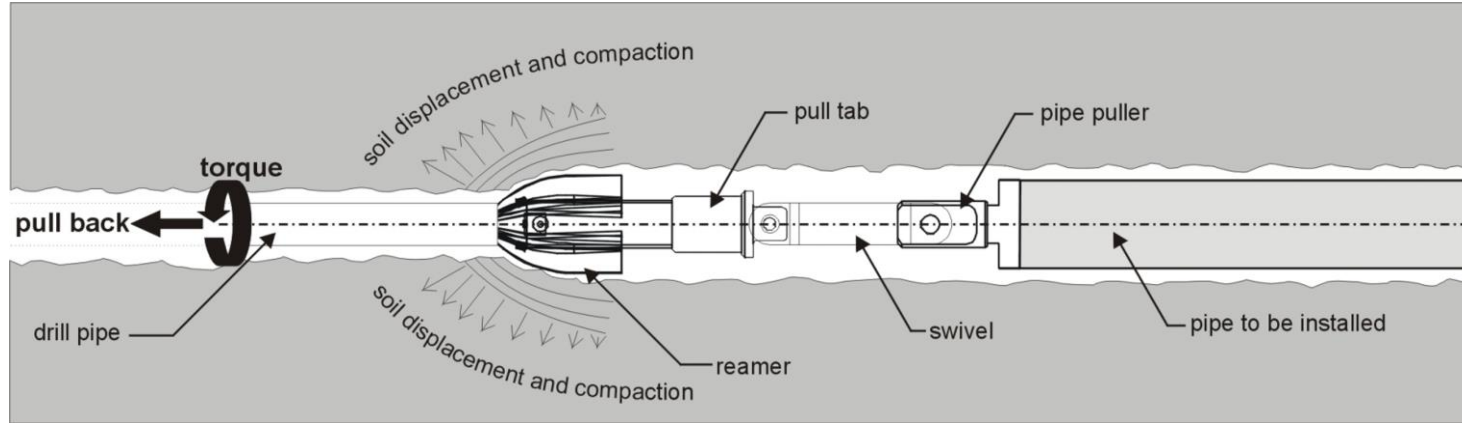
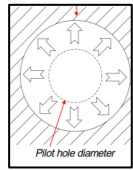


Crushing (impact)

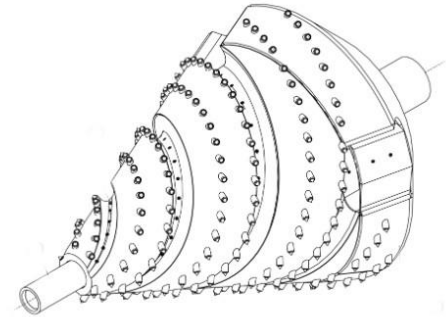


MAIN DRILLING MECHANISMS IN SOIL AND ROCK

Displacement



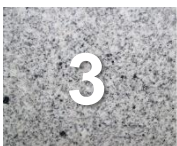




Barrel reamer
(compacting)



Fluted reamer
(combined cutter-compacting)



	Soil conditions	OPERATIONAL STAGE		Main drilling mechanism
		PILOT	REAMING	
		System/Tooling		
	Soft fine soil jettable (sand, silt, clay, peat and combinations)	<ul style="list-style-type: none"> • Plate bits 	<ul style="list-style-type: none"> • Cutting reamers • Mixing reamers • Barrel reamers 	<ul style="list-style-type: none"> • Jetting • Cutting/Scraping • Displacement
	Hard fine soil but jettable	<ul style="list-style-type: none"> • Jetting assembly 	<ul style="list-style-type: none"> • Compacting reamers • Combined (mix of previous categories) 	
	Rock formations	<ul style="list-style-type: none"> • Mud motor: TCI/Mill tooth roller cones, PDC bits • Dual-rod system: TCI/Mill tooth roller cones, PDC bits • DTH Hammer: TCI hammer bits (slanted, eccentric) • Soft rock/hard ground slanted bit 	<ul style="list-style-type: none"> • Hole openers: TCI/Mill tooth roller cones • Shark teeth reamer (solid body) • PDC reamers 	<ul style="list-style-type: none"> • Crushing (compression) • Crushing (impact) • Cutting/Scraping
	Mixed formations, gravelly sandy (<u>stable</u> borehole)	<ul style="list-style-type: none"> • Soft rock/hard ground slanted bit • Dual-rod system: TCI/Mill tooth roller cones, PDC bits • DTH Hammer: TCI hammer bits (slanted, eccentric) 	<ul style="list-style-type: none"> • Combined • Hole openers: TCI/Mill tooth roller cones • Compacting reamers 	
	Coarse to very coarse unconsolidated formations (<u>unstable</u> borehole)	<ul style="list-style-type: none"> • Stabilization methods (casing, cementing, other methods) • Soft rock/hard ground slanted bit • DTH hammer: TCI hammer bits (slanted, eccentric) 	<ul style="list-style-type: none"> • Combined 	

Disclaimer: this chart has been elaborated by DCA with the sole scope to facilitate the discussion about tooling selection during the DCA Members Forum 2022. The soil classification, the system/tooling and the main drilling mechanisms showed in the present chart are based on industry well-accepted criteria and common knowledge. The selection of tooling and drilling technique must be carried out, based on specific soil investigation, project characteristics, appropriate design and engineering judgment. The DCA, its boards and the DCA's members who elaborated or presented the present chart are not liable for any damage or consequence resulting from the use of the present chart.