wassara

STRAIGHT FORWARD DRILLING

2012-10-28 LKAB Wassara AB

LKAB Wassara AB

- **100% owned by LKAB** (owned by the Swedish state)

- Development and Manufacturing of: **Water Powered Percussion Hammers**

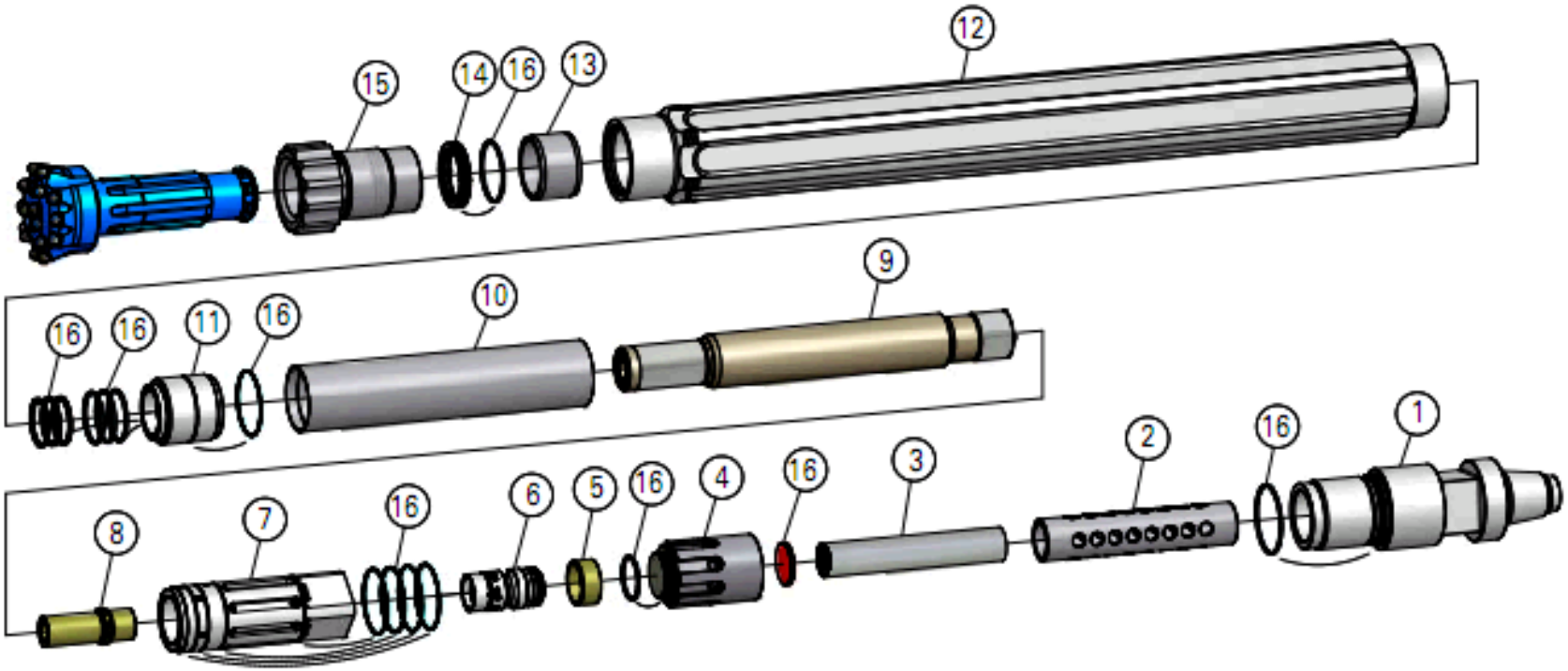
- Marketing and Sales: **Through distributors**
- Facilities: **Drill Center**: Malmberget
  Manufacturing Huddinge: Stockholm
  R&D, Marketing & Sales, Headoffice: Stockholm
- Sales 2011: **10 M€**
- **40 employees**

The LKAB Group in brief

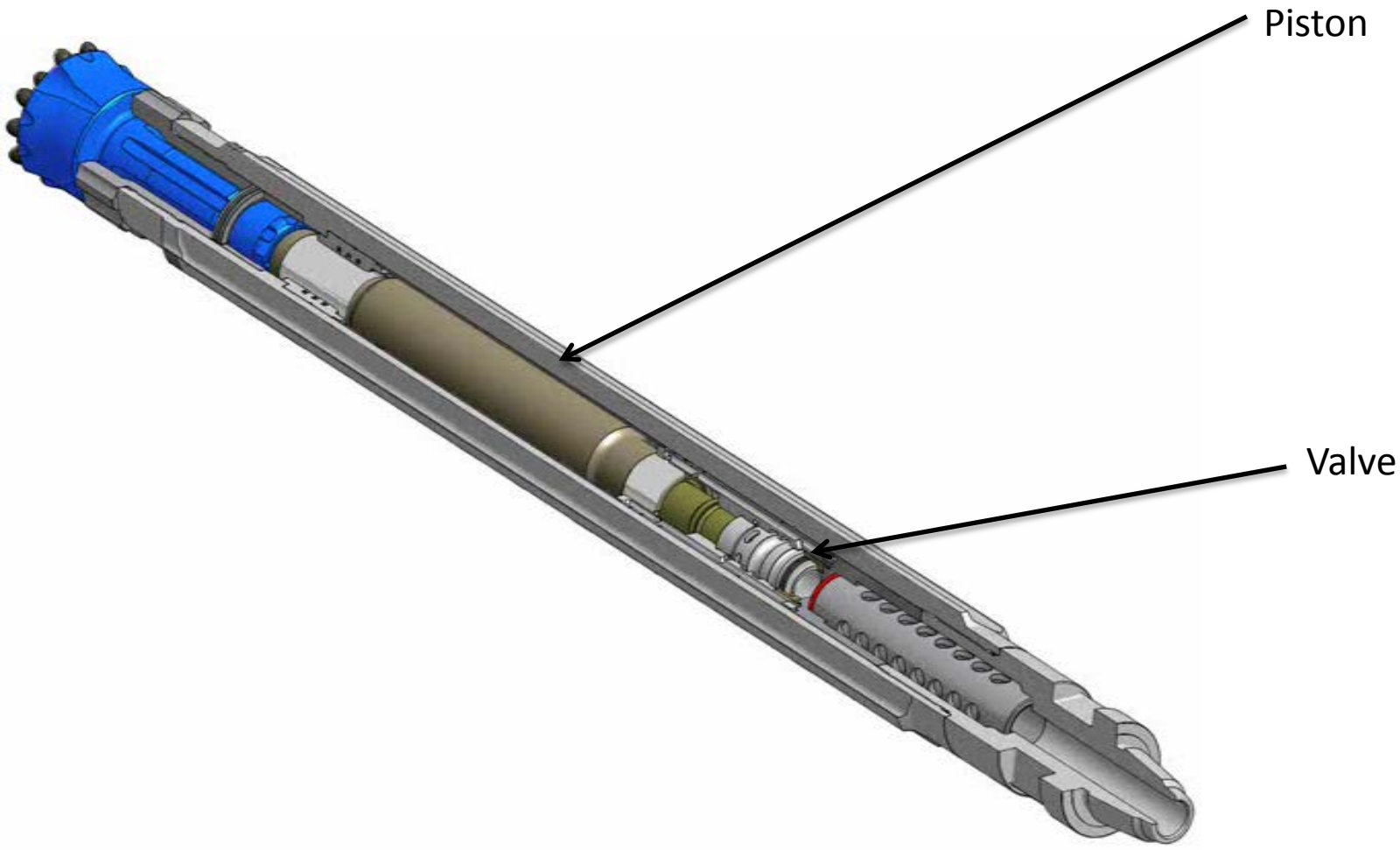
- Sales 2011: 31,1 BSEK, Income: 14,8 BSEK
- 4100 employees
- World leader in underground mining (Kiruna and Malmberget)
- World-leading in pellet manufacturer for more than 50 years
- 90% of the EU's iron ore production

wassara

The Wassara Water Hammer



Two moving & Interacting parts



Hammer Range

Hammer	Ø Drill bit	Water cons.	Op. Pressure
W50 (2'')	60mm, 64mm (2 ⅜'', 2 ½'')	80-130 l/min (20-35 USgpm)	170 bar (2500 psi)
W70 (3'')	82mm, 89mm (W-Bit™) (3 ¼'', 3 ½'')	130-260 l/min (35-70 USgpm)	180 bar (2600 psi)
W80 (3.5'')	95mm (3 ¾'')	130-260 l/min (35-70 USgpm)	180 bar (2600 psi)
W100 (4'')	115mm, 120mm (4 ½'', 4 ¾'')	225-350 l/min (60-95 USgpm)	180 bar (2600 psi)
W120 (5'')	130mm, 140mm (5 ⅛'', 5 ½'')	300-450 l/min (80-120 USgpm)	180 bar (2600 psi)
W150 (6'')	165mm (6 ½'')	350-500 l/min (95-130 USgpm)	150 bar (2200 psi)
W200 (8'')	216, 254mm (8 ½'', 10'')	470-670 l/min (125-180 USgpm)	150 bar (2200 psi)

Key Benefits

- **High drilling performance**
- **Economics & Environmentally friendliness**
- **Safer & benign drilling**
- **Drill hole quality**

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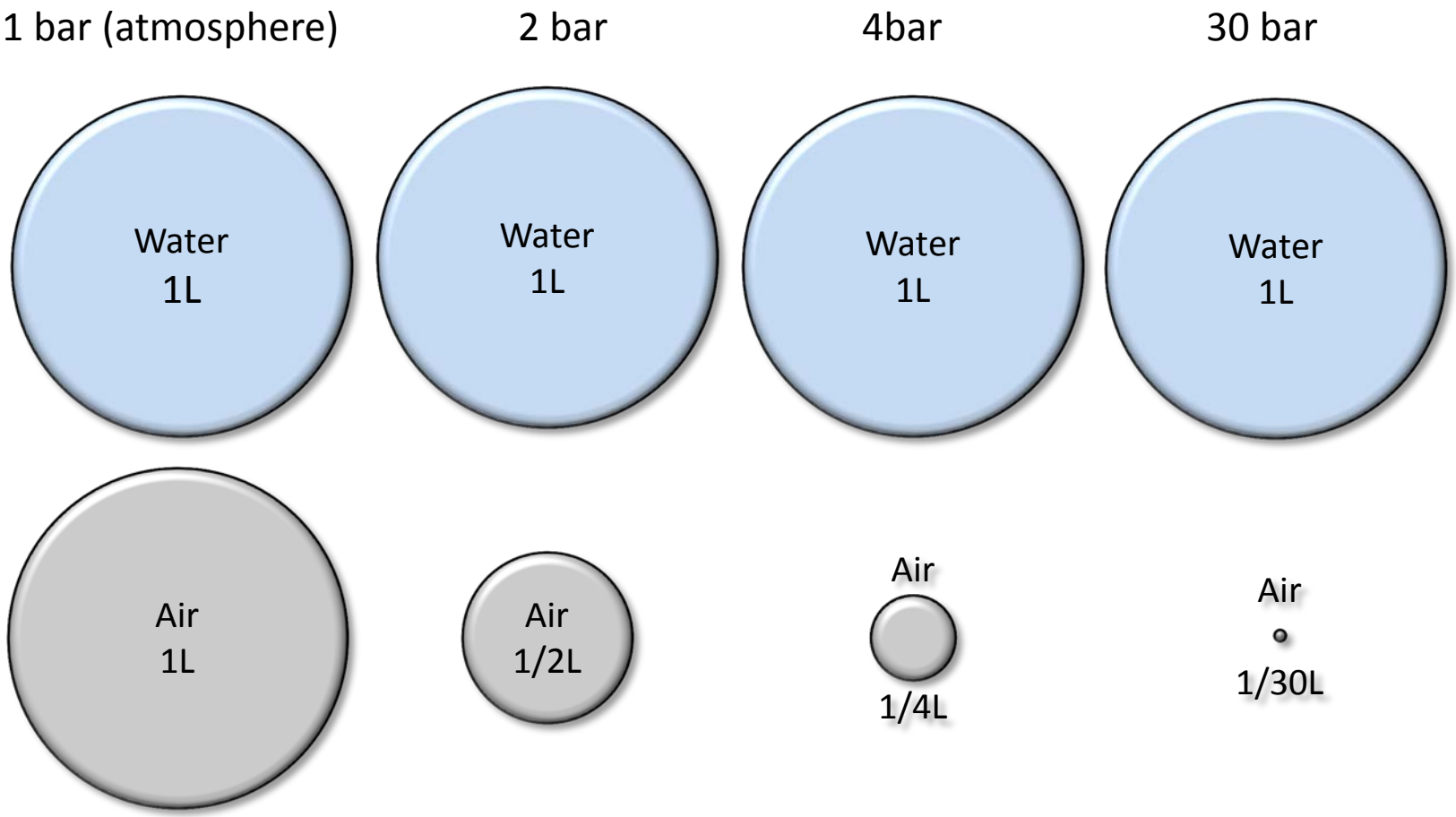
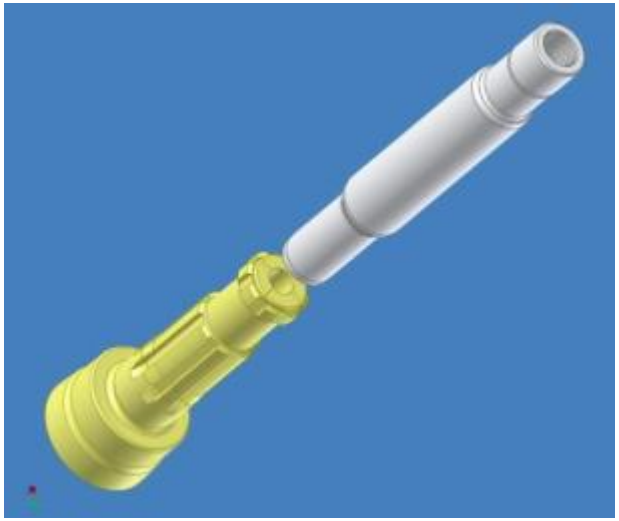
Pressure ~ Flow correlation



High Power Output

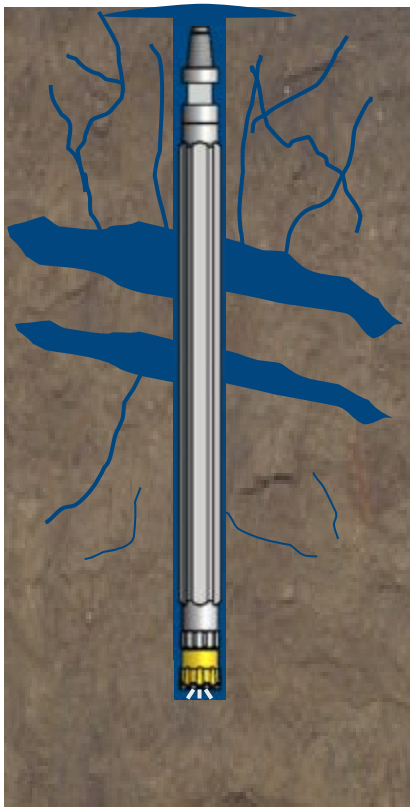
Hammer	Pressure	Flow	Frequency
Wassara W100 (4’’)	180 bar (2600 psi)	3,5-6 l/s (225-350 l/min) 7.5-13 cfm (60-95 USgpm)	**3600** blows per minute (60 Hz)
Air ITH 4’’	30 bar (435 psi)	350-450 l/s (740-950 cfm)	**2000-2700** blows per minute (35-45 Hz)



High power output,

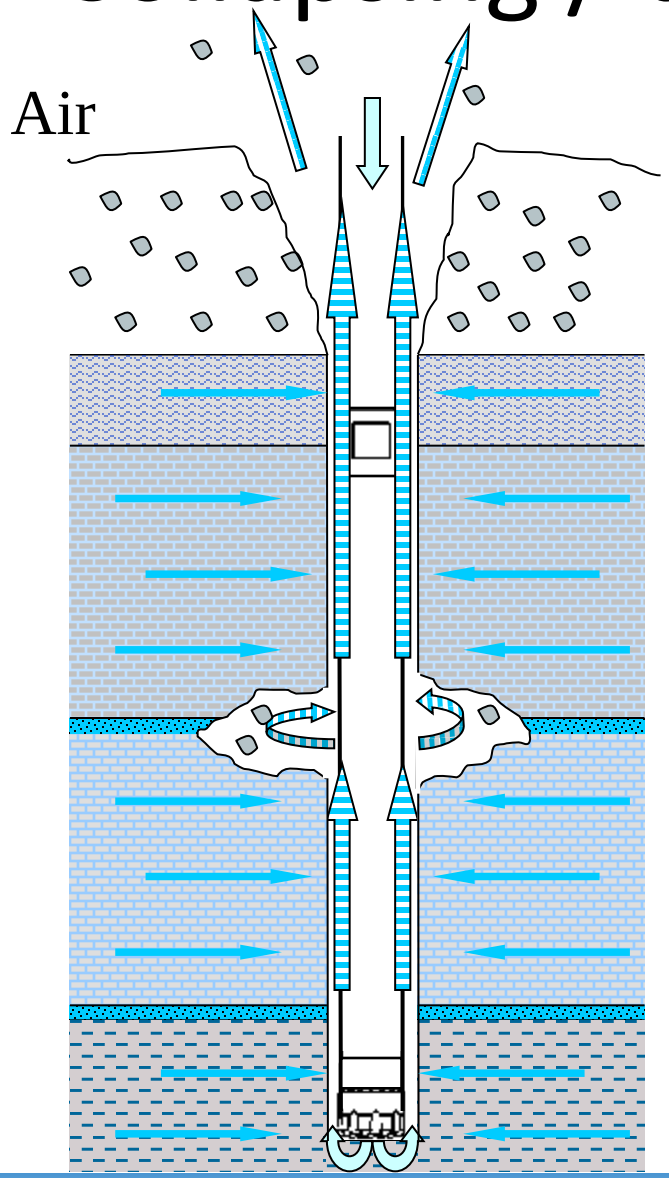
due to high frequency

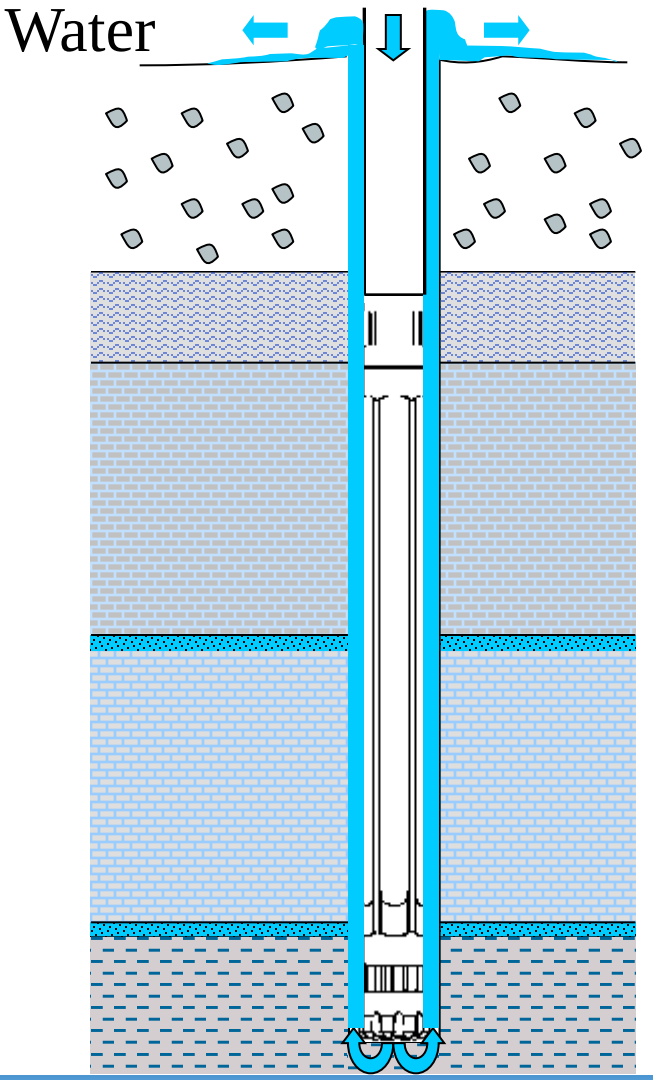
Facilitates drilling in water rich formations



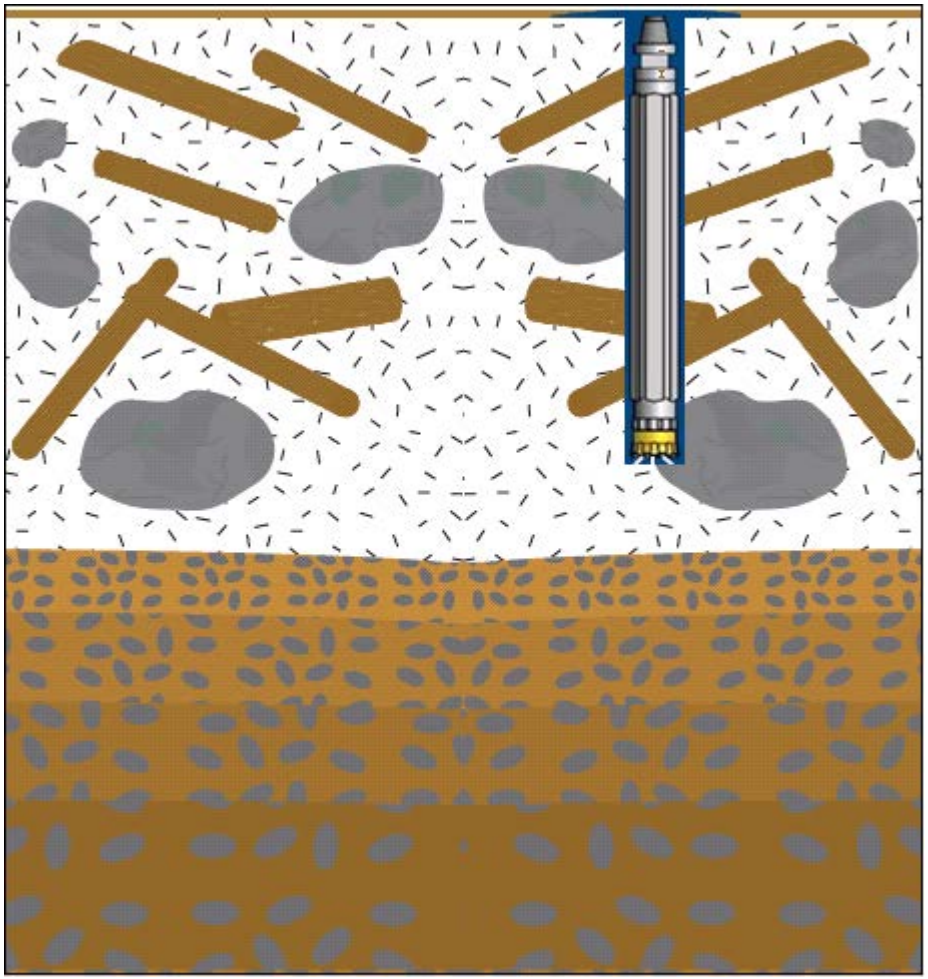
Water in the formation does not affect the Wassara hammer

Collapsing / unstable formations





Effective drilling through wood



The Wassara water hammer has proven to penetrate fill layer with heavy logs and blocks of stone from earlier buildings much more effective than other drilling methods.

Key Benefits

- High drilling performance
- **Economics & Environmentally friendliness**
- Safer & benign drilling
- Drill hole quality

Power Station

vs

Air ITH (air cons.)	
4''	350-450 l/s (740-950 cfm)
5''	500-600 l/s (1050-1250 cfm)
6''	550-650 l/s (1200-1400 cfm)

Air Compressor	Water Pump
35 bar (510 psi)	200 bar (2900 psi)
570 l/s (1207 cfm)	490 l/min (129 USgpm)
429kW (575 hp)	**190kW** (255 hp)

Wassara (water cons.)	
W100 (4'')	225-350 l/min (585-95 USgpm)
W120 (5'')	300-450 l/min (80-120 USgpm)
W150 (6'')	350-500 l/min (95-130 USgpm)

Energy consumption

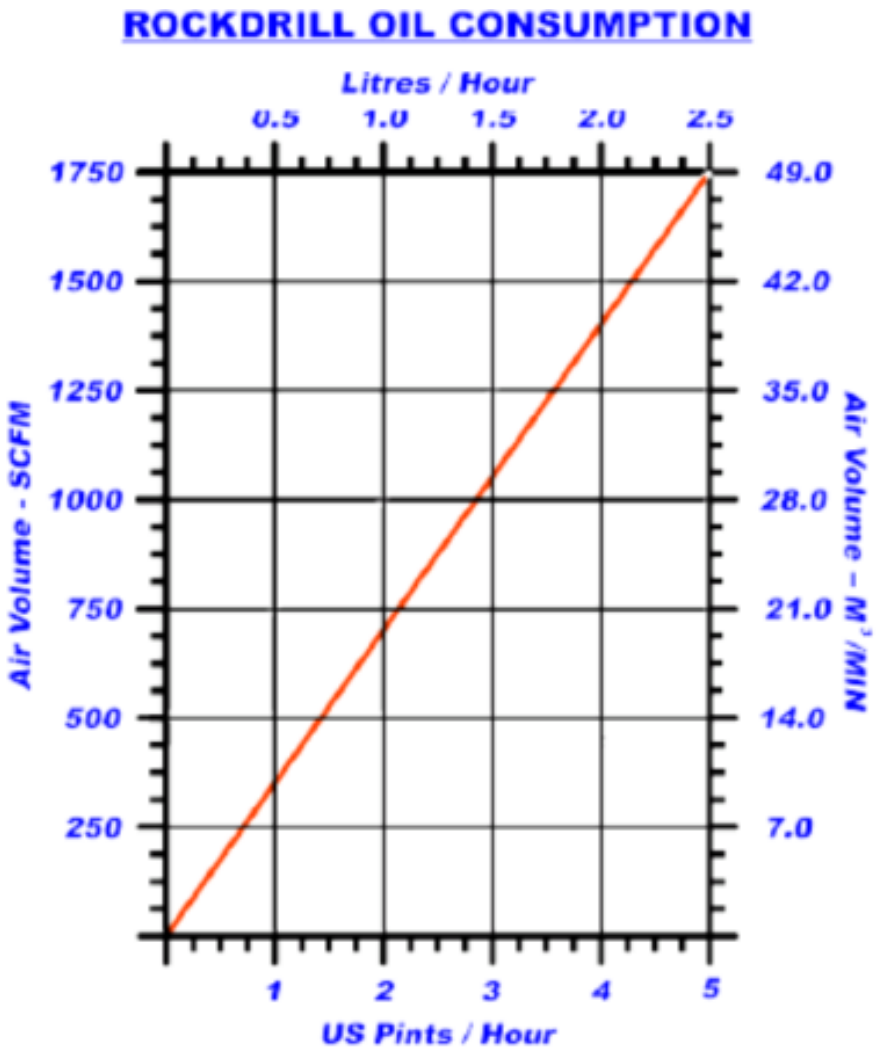
Air compressor

-

Water pump

- ***Reduction of energy consumption by 80 %***

No oil for lubrication



- No oil in the ground
- No oil mist in the air

Working environment

AMV drill with Air ITH

AMV drill with Wassara

- No oil mist in the air

- No dust

Underground mining
when caring for the working environment

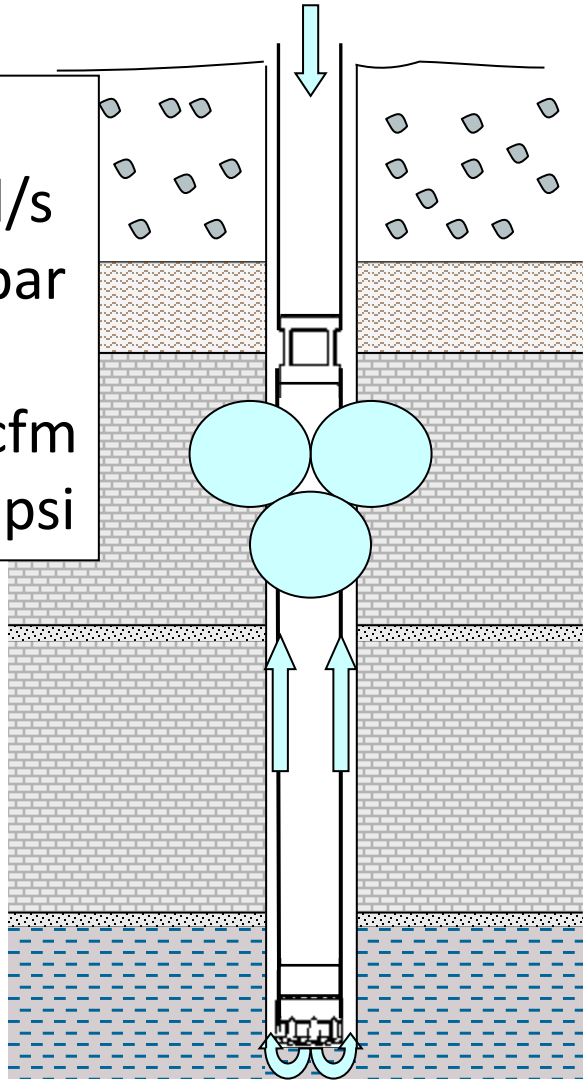
Key Benefits

- High drilling performance
- Economics & Environmentally friendliness
- **Safer & benign drilling**
- Drill hole quality

Incoming

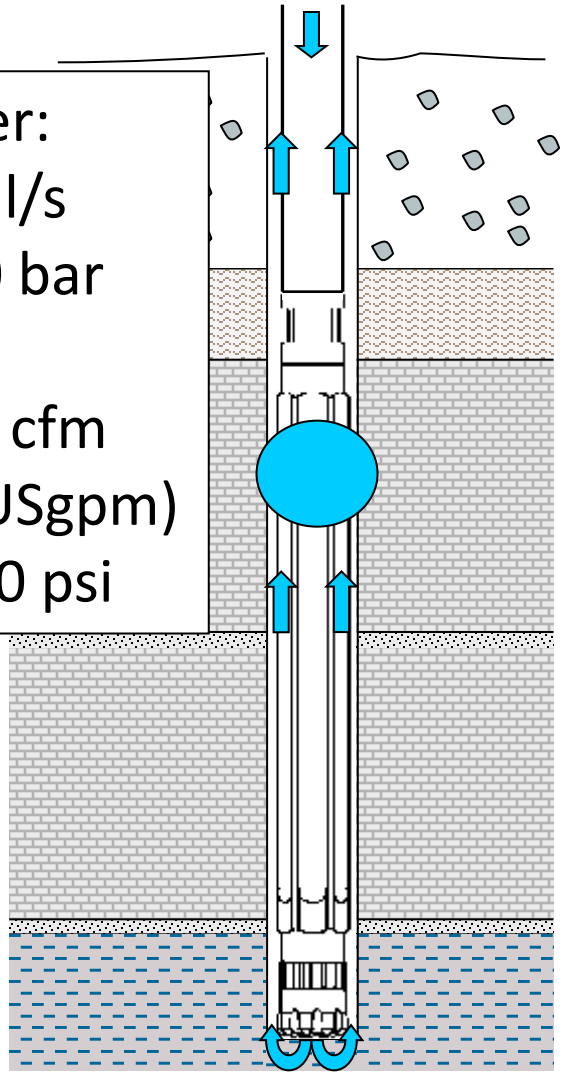
Air:
15-20 l/s
@ 30 bar

30-40 cfm
@ 435 psi



Water:
3,5-8 l/s
@ 180 bar

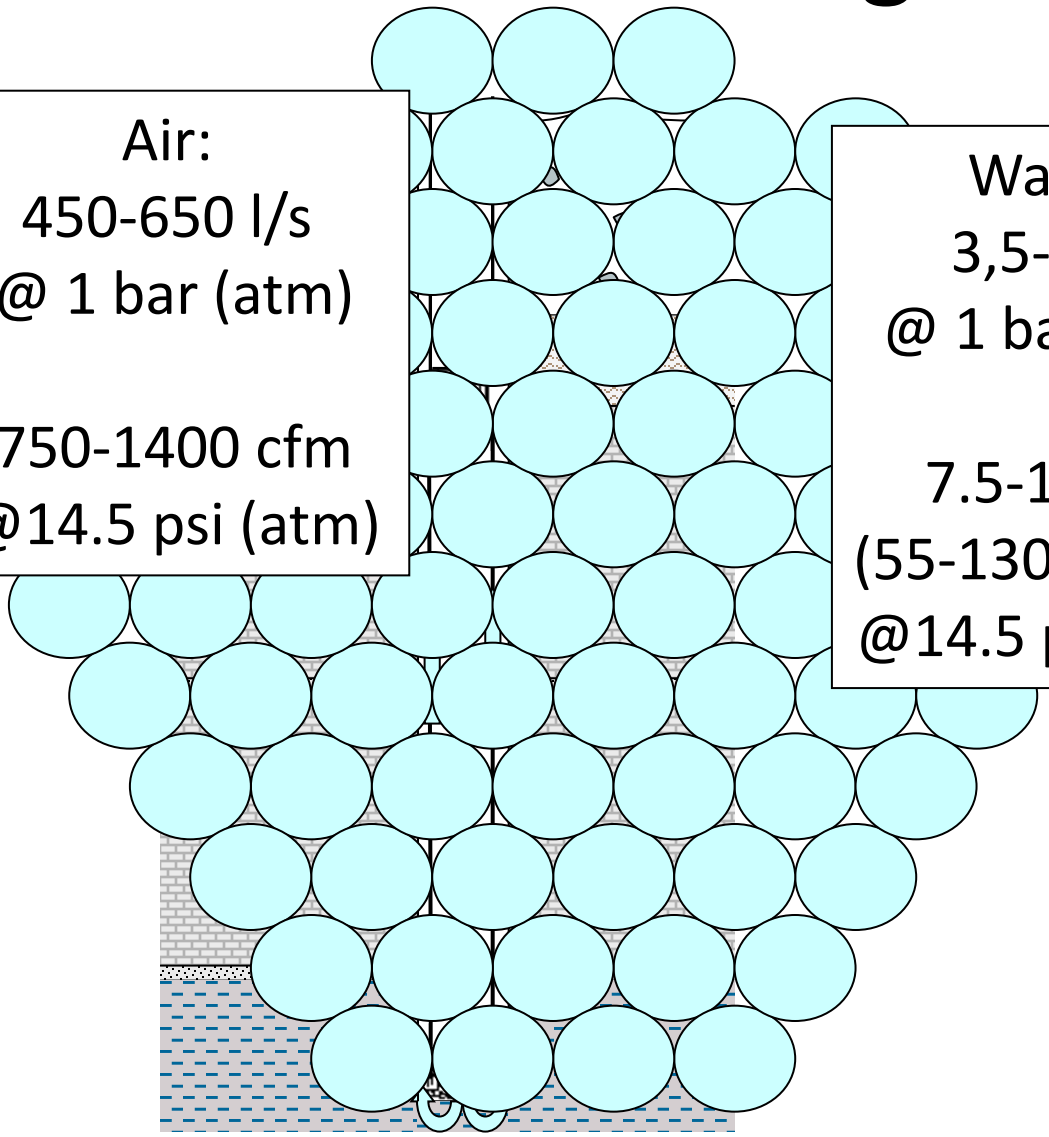
7.5-17 cfm
(55-130 USgpm)
@ 2600 psi



Outgoing

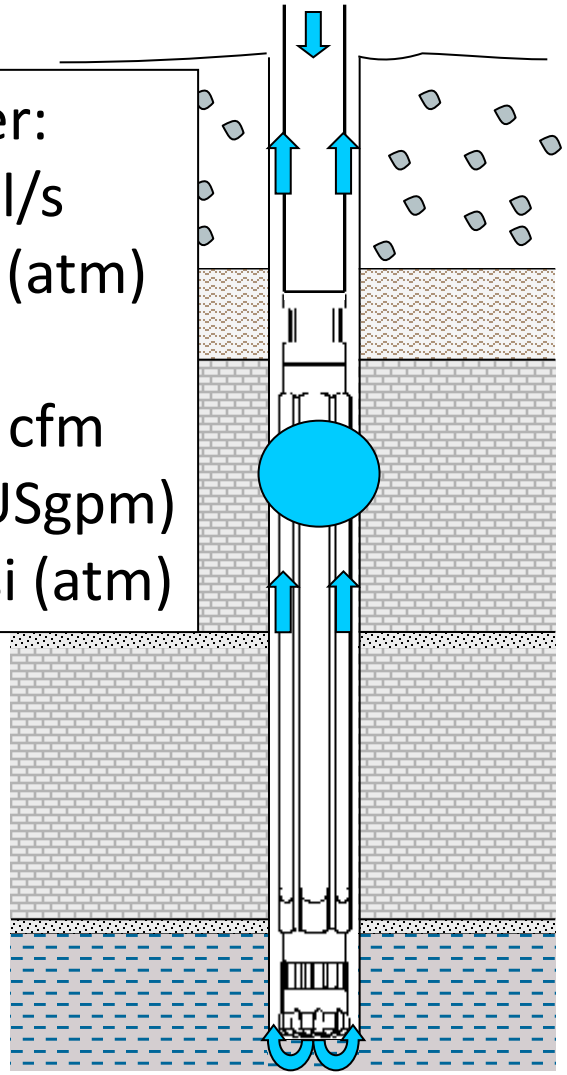
Air:
450-650 l/s
@ 1 bar (atm)

750-1400 cfm
@14.5 psi (atm)



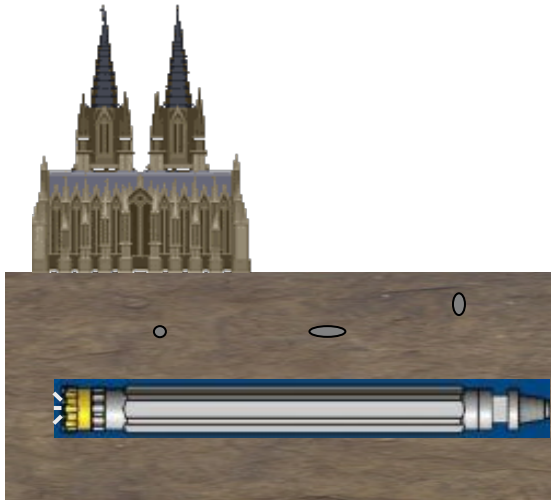
Water:
3,5-8 l/s
@ 1 bar (atm)

7.5-17 cfm
(55-130 USgpm)
@14.5 psi (atm)

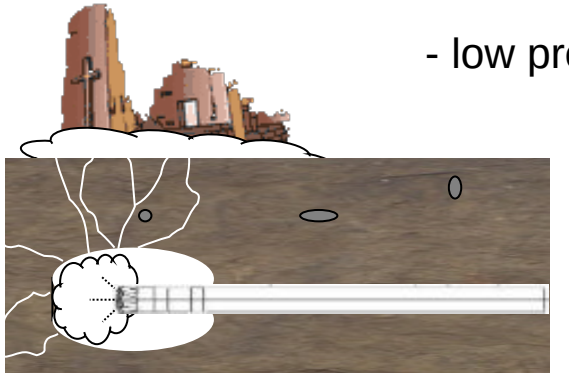


Minimum disturbance to the formation

Wassara

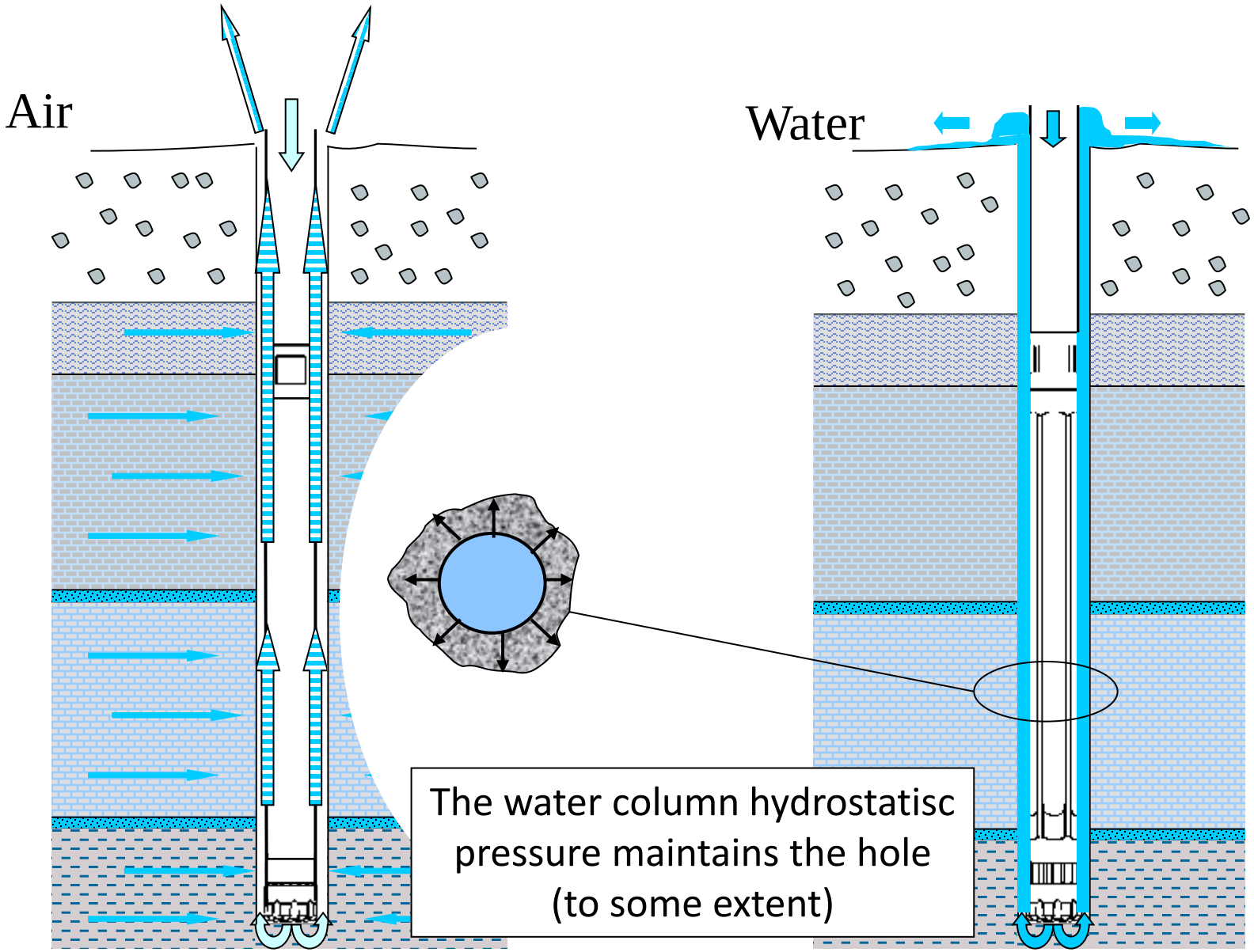


Air DTH



Minimal outgoing water velocity

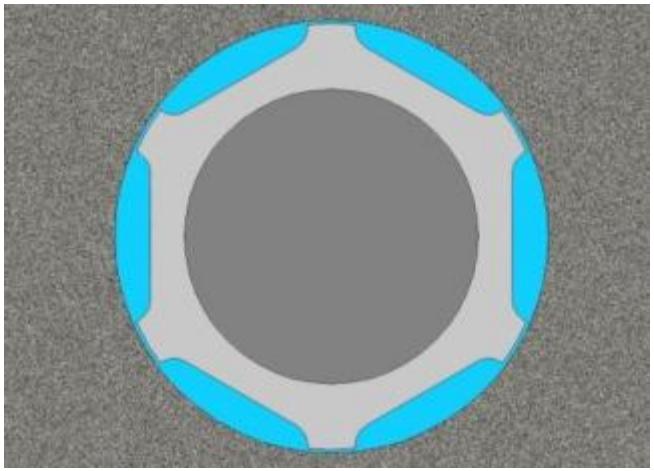
- low pressure!

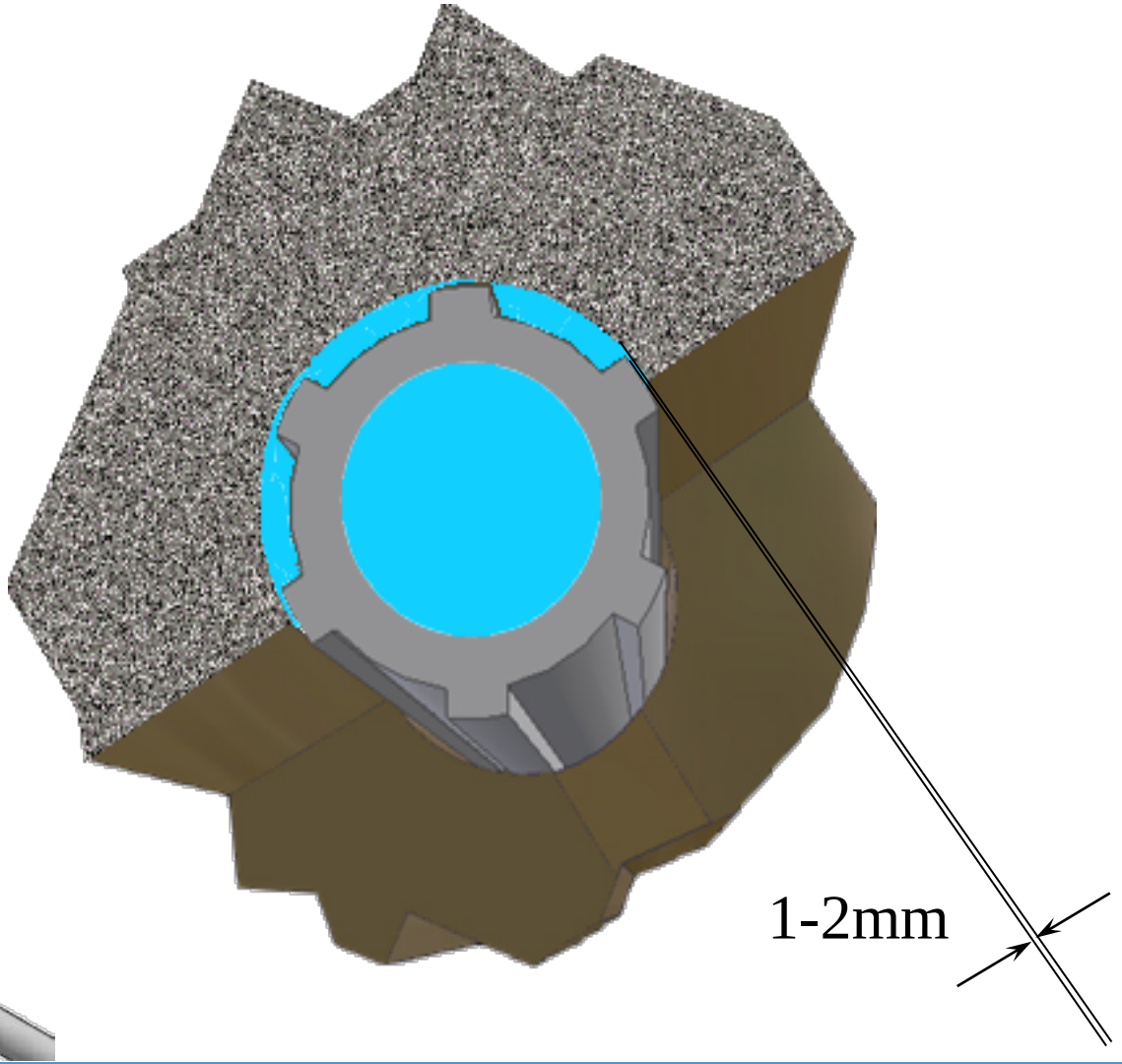

Air
Water
The water column hydrostatisc pressure maintains the hole (to some extent)

Key Benefits

- High drilling performance
- Economics & Environmentally friendliness
- Safer & benign drilling
- **Drill hole quality**

Tight spacing



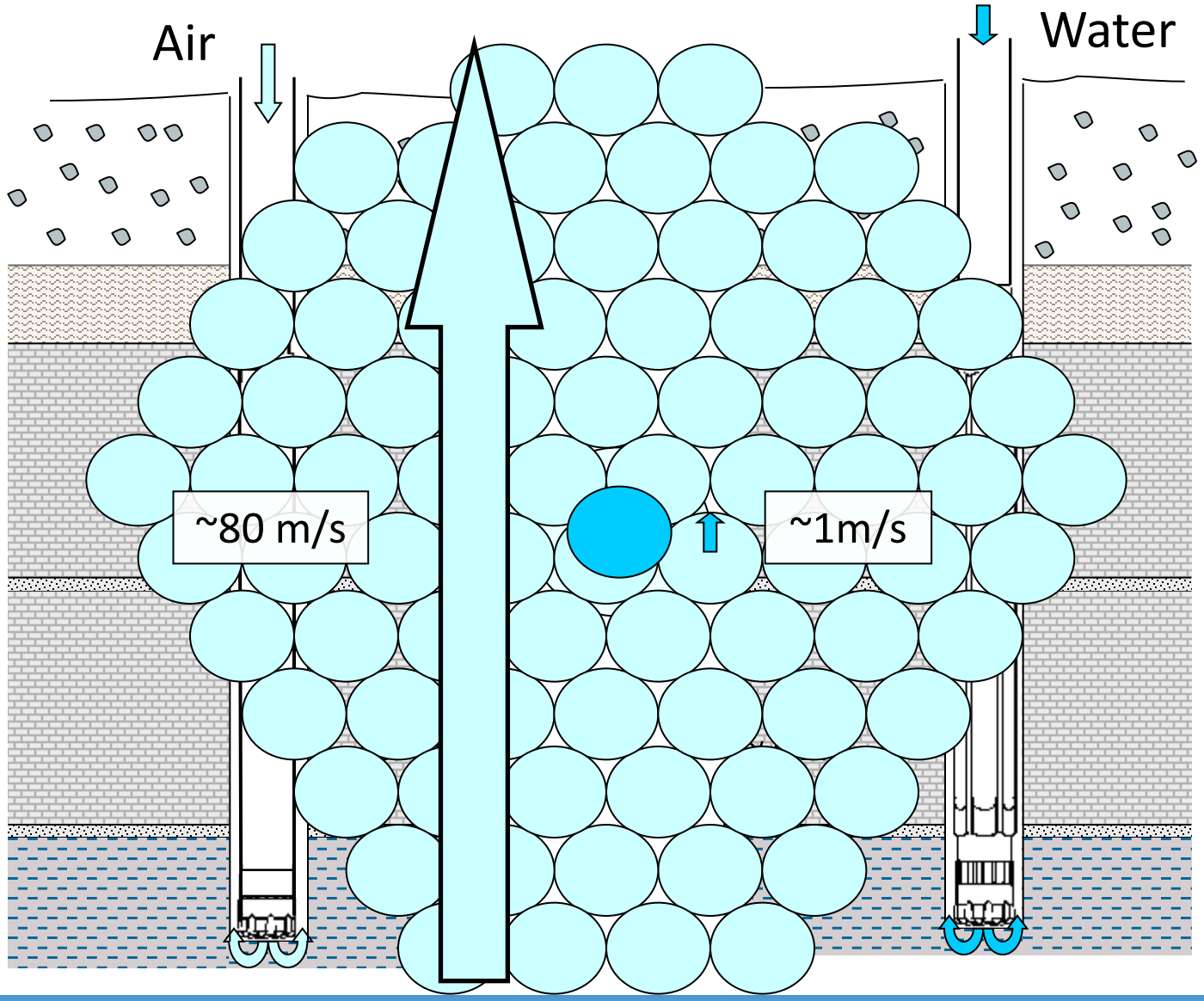


Low flow and velocity of cuttings

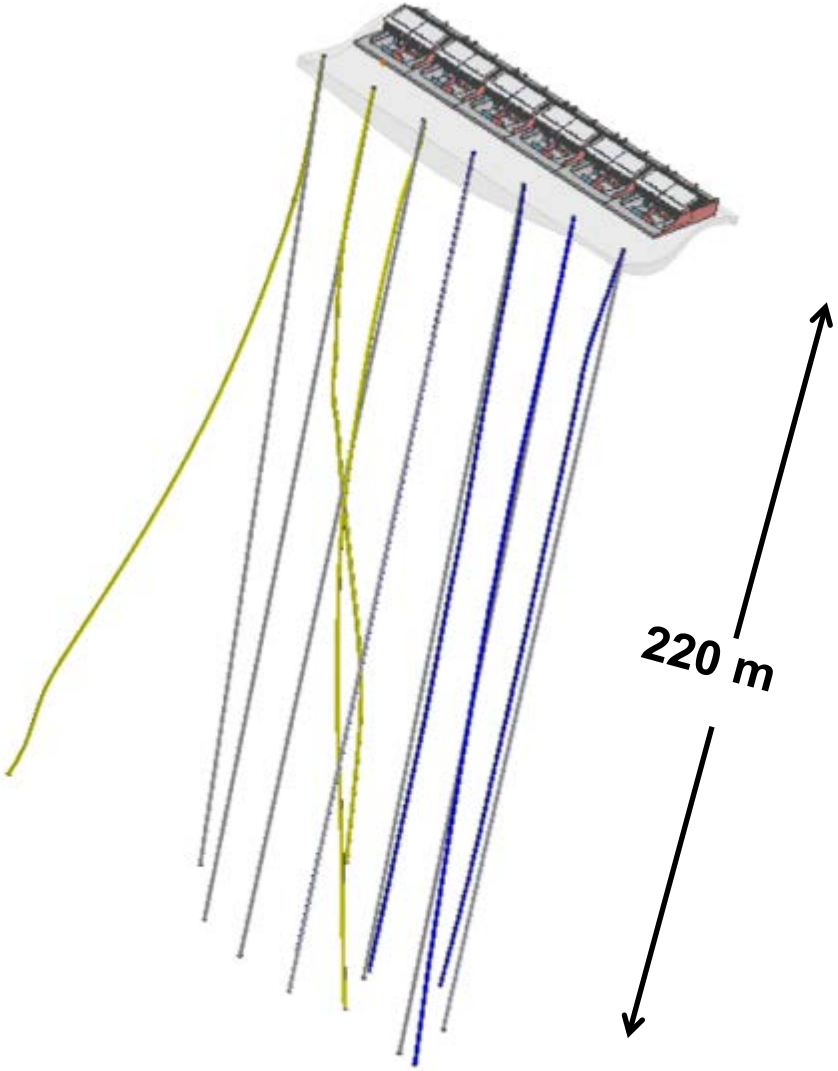
$$E = \frac{m * v^2}{2}$$

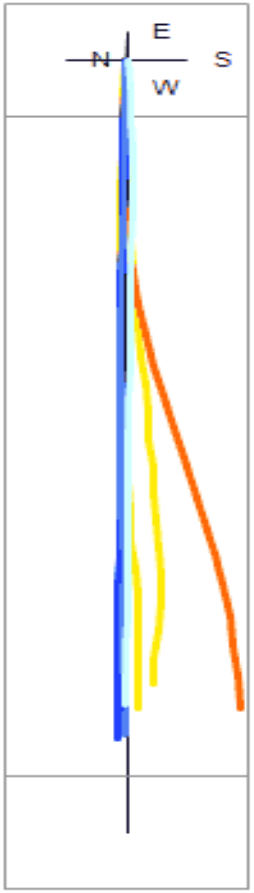
E_{air}=m*3200 J

E_{water}=m*1 J



Geothermal Project in Stockholm





Average deviation 19,2%

Air

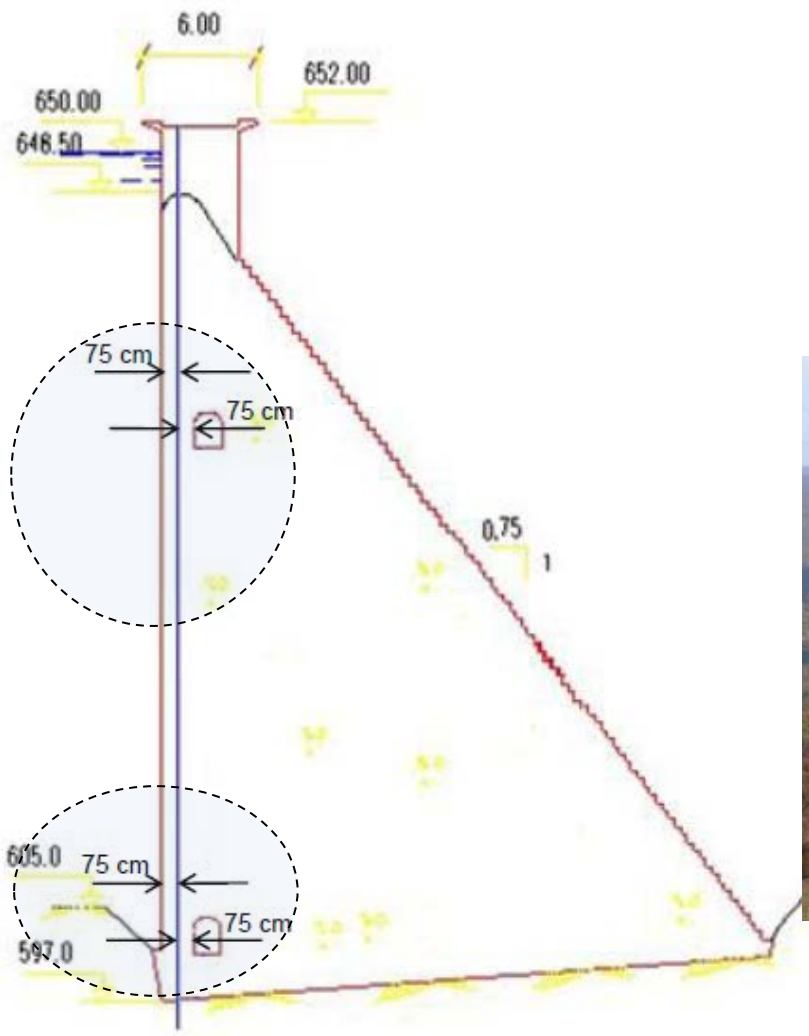
- Hole 1
- Hole 2
- Hole 3

Wassara

- Hole 4
- Hole 5
- Hole 6
- Hole 7

Average deviation 1,3%

Urdalur Dam, Spain



The contractor Keller Terra had only 75 cm from the center of the bore hole to the dam wall (on one side), and, dito to the side of the wall of the two existing drainage/service tunnels (on the other side)

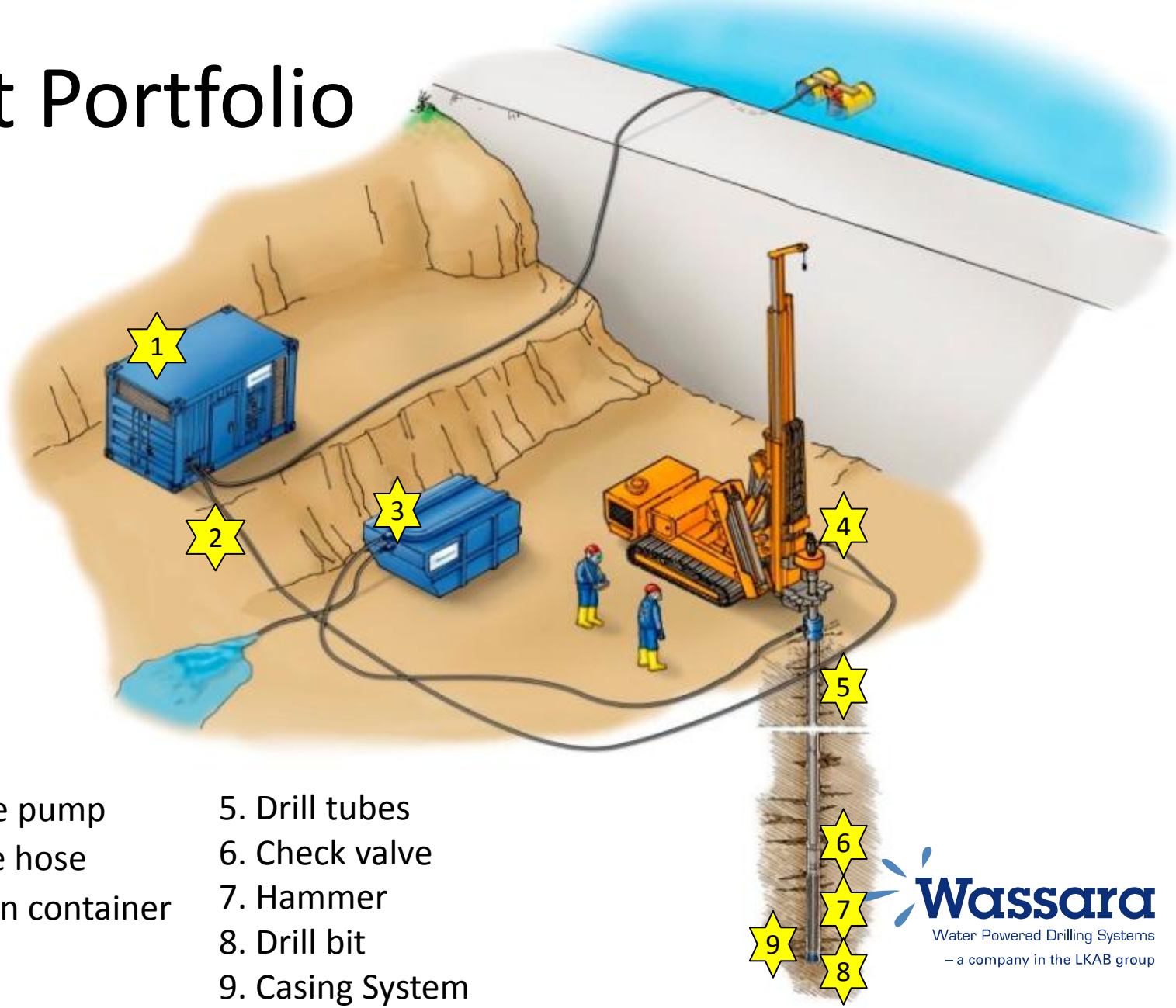
Clean Hole

Increased productivity and quality in the grouting process.

Torch!

Bore hole quality: Accuracy within given limits < 1%.

Product Portfolio



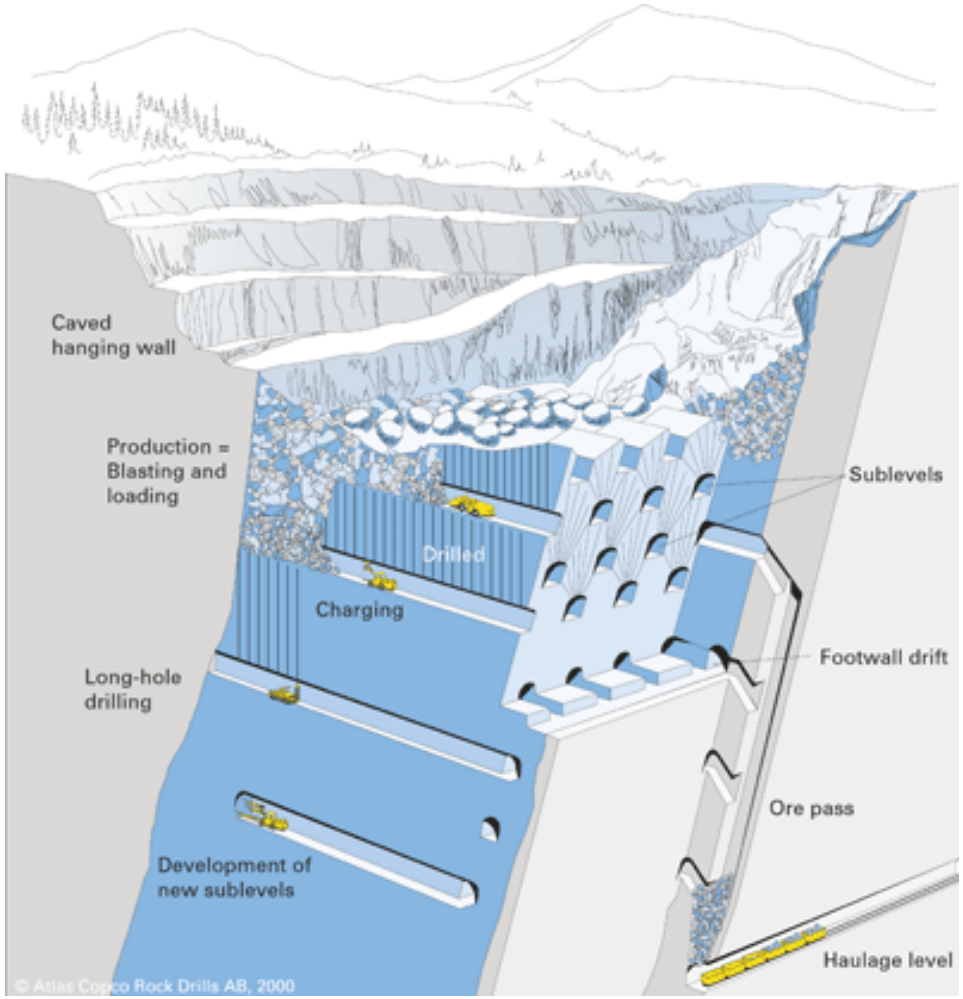
1. High-pressure pump
2. High pressure hose
3. Sedimentation container
4. Swivel
5. Drill tubes
6. Check valve
7. Hammer
8. Drill bit
9. Casing System

Wassara
Water Powered Drilling Systems
– a company in the LKAB group

Wassara Focus Segments

Kiruna & Malmberget Mines

Sub Level Caving



- Dilution
- Fragmentation
- Energy Consumption
- Working environment
  - oil mist in the air
  - dust / silicosis

Moving Boundries

Indirect cost reduction

Larger scale of operation,
means lower cost per tonne

1995, 28m **10.000** tons

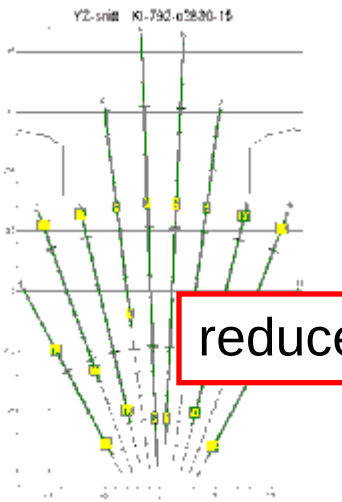
Drilling acc: 1%

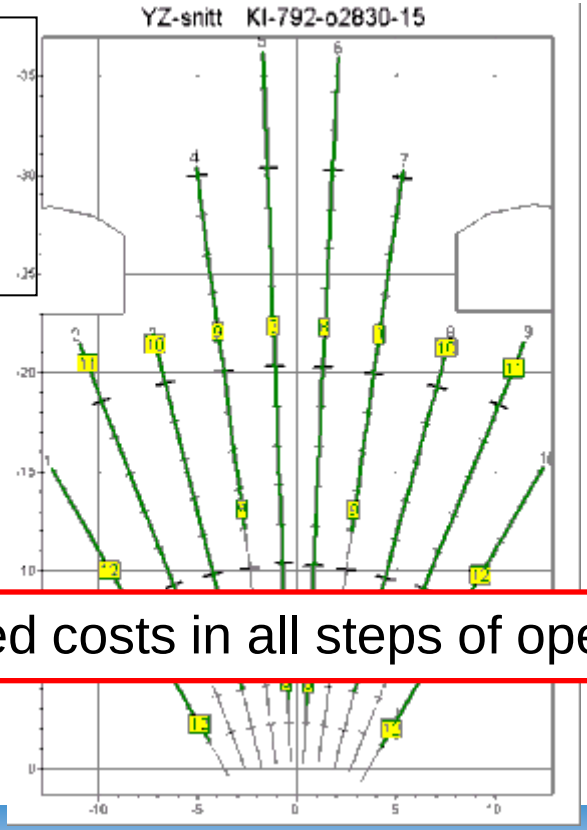
Energy cons: 10%

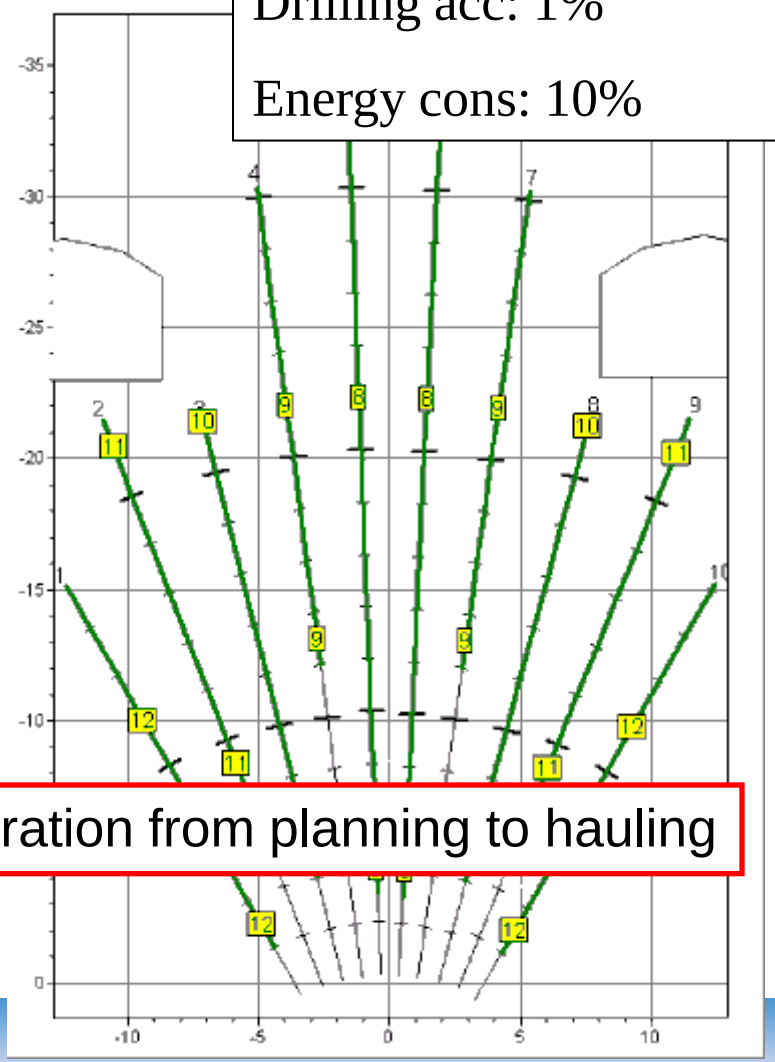
1991, 22m

1985, 12m **1.200** tons

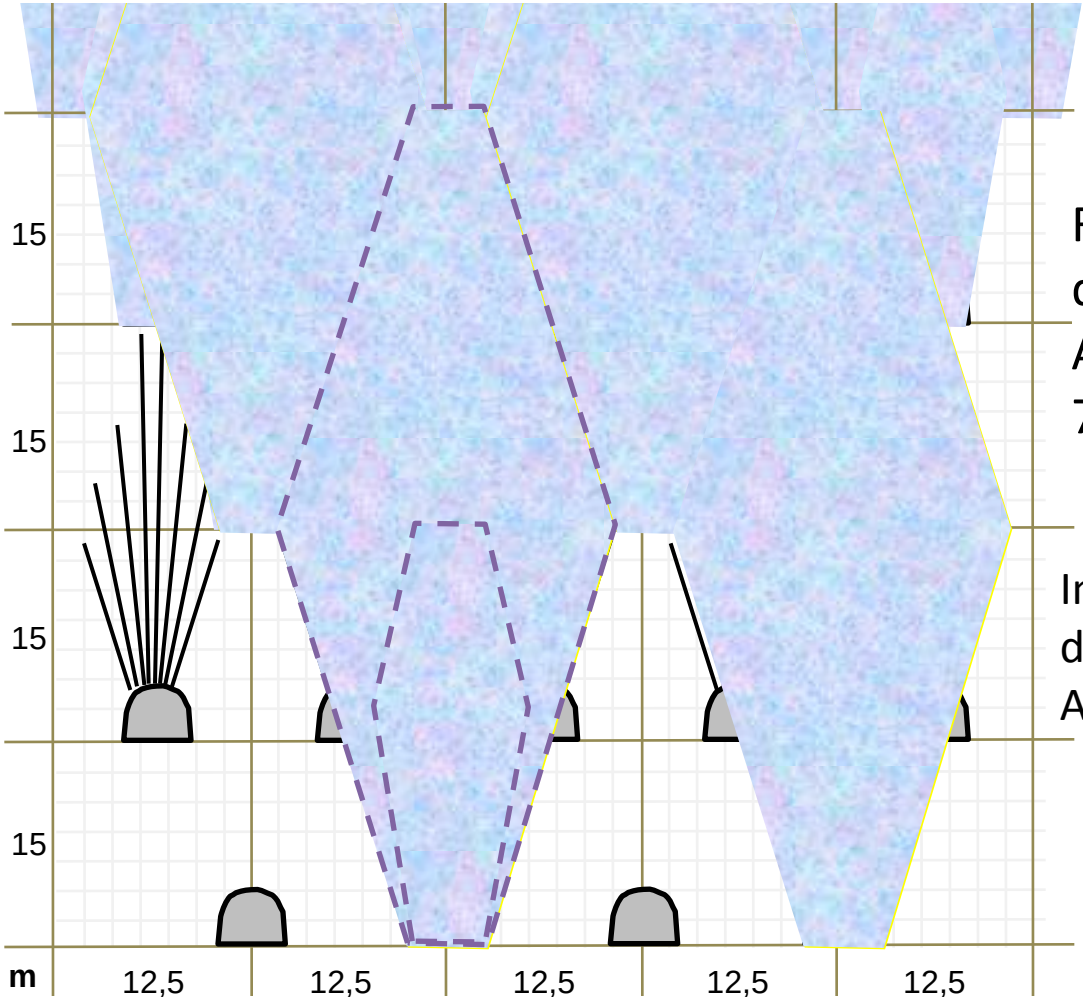
Drilling acc: 5-15 %







reduced costs in all steps of operation from planning to hauling

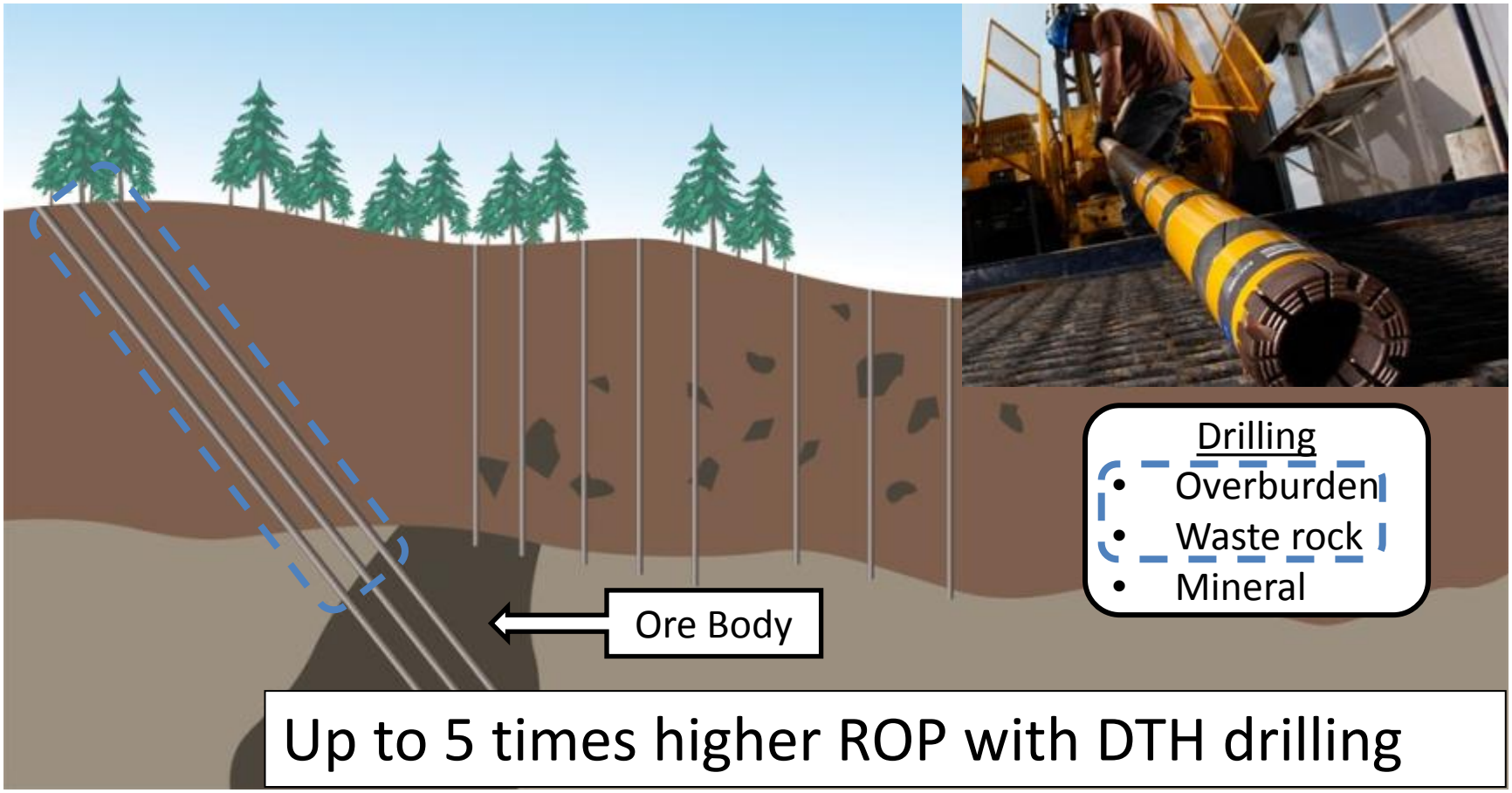


Reduction of drifts: Approximately 70 %

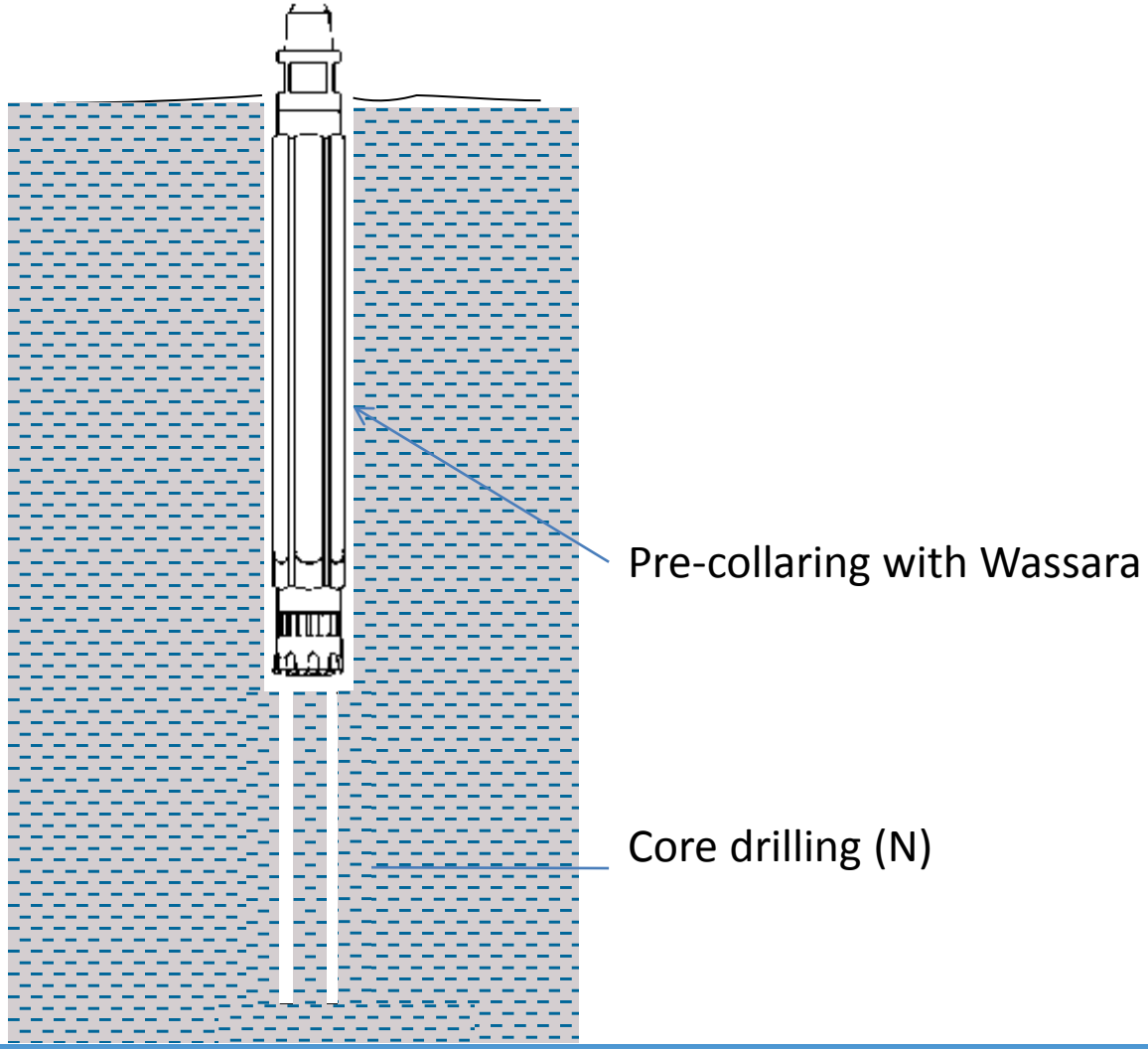
Increased volume per drilled meter: Approximately 500%

Focus Segment

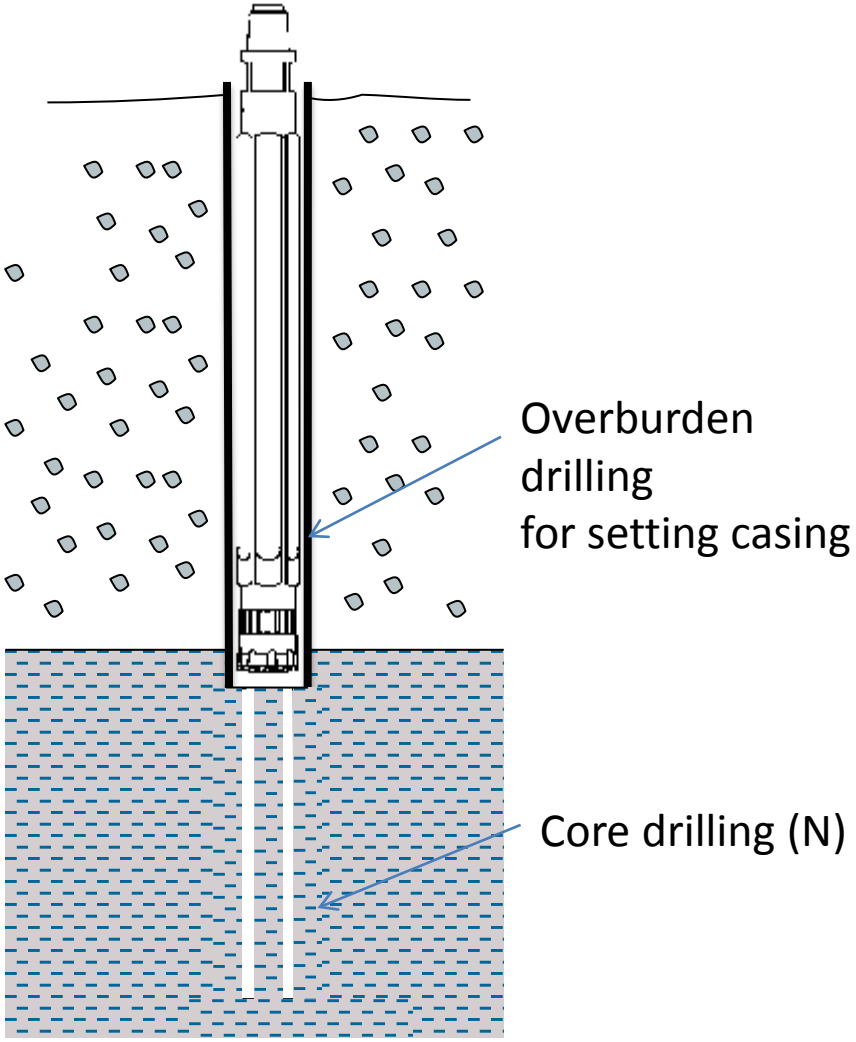
Mineral Exploration



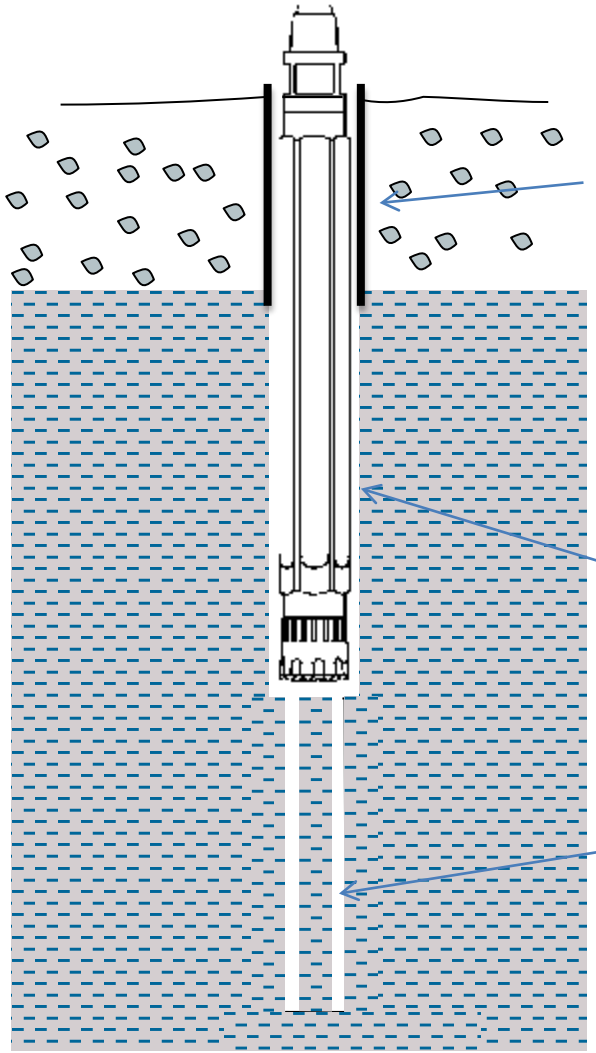
Wassara offer – underground/surface



Wassara offer – surface



Wassara offer – surface

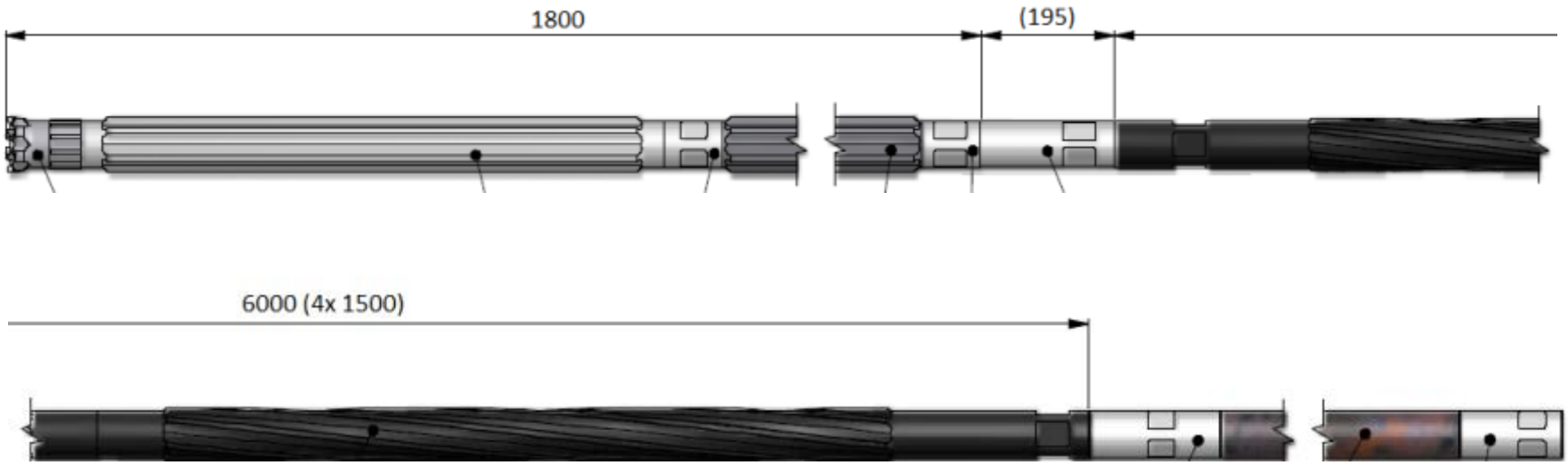


Overburden drilling
for setting casing

Pre-collaring with Wassara

Core drilling (N)

BHA – Bottom hole assembly (N-size)



1	Drill bit ∅82 / 81mm	6	Check Valve
2	Piston Casing (∅79,5mm / ∅80,5mm)	7	Weight Rods (4x 1,5m)
3	Front Sub	8	Adapter WT70box-NQbox
4	Guided drill tube (∅79,5mm / ∅80,5mm)	9	N-size drill tubes
5	Top Sub	10	Adapter NQpin-G 1 1/4’

Time saving – scenarios

Application	**Underground**
Hole depth	**400 m**
Dimension	**N-size (76 mm)**

Scenario 1:

400 m core drilling

Time needed, 135 h

Scenario 2:

200 m Wassara drilling with W70 hammer

+ 200 m core drilling

Time needed: 75 h (10+65 h)

Saving: 45% faster

Test site: Malmberget, Sweden

Onram 1000 (Sandvik / Hagby)

Wassara Projects

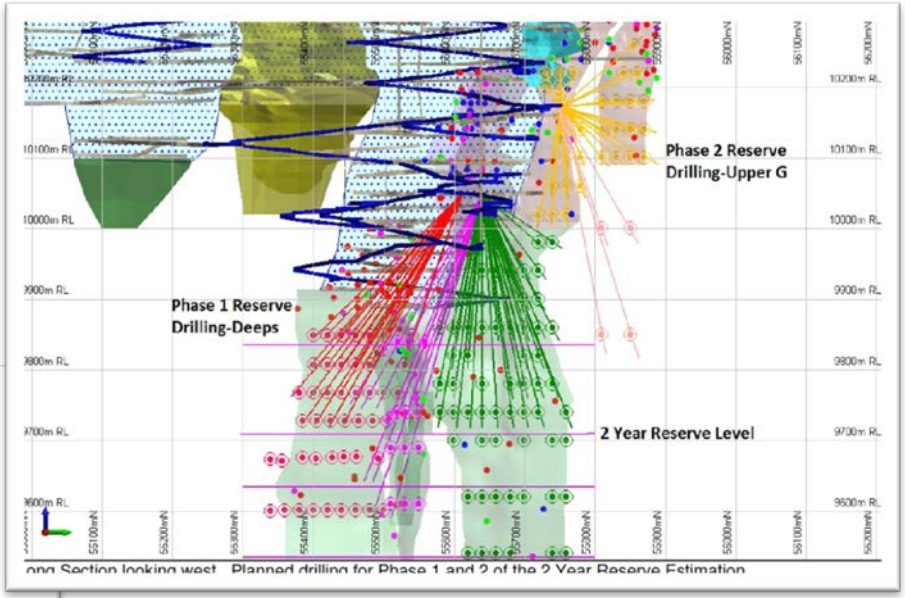
– Exploration Drilling - Poseidon Nickel, WA Australia (1)

- A ‘new’ high grade nickel sulphide mine production planned commencement in 2014. 10.000 ton out put phase1.
- Mt Windarra -12 month construction time-line. Initial exploration drilling program planned for 30 month! Timeline for verifying grades critical for financing.
- 10 years initial resource life, total remaining capital investment approx. 200 MAUD
- Drilling starts in November, 2012. 3km of decline refurbished. Due to Wassara exploration drilling can start at 500m level and be 50% faster than coring for collaring phase.
- Initial interest was for production drilling after visit to LKAB & Swedish Mining Exhibition

Wassara Projects

– Exploration Drilling - Poseidon Nickel, WA Australia (2)

- Wassara pre-collaring , then NQ2 core, or where needed BQ.
- Phase1, downhole dips -19° to -65°.
- Collars mainly through basalt, passing through ultramafics and terminating past ore body.



Scope Of Works

Phase 1 Program- Windarra CDG Deeps: 2 Year Reserve Delineation from 10050 Level

Drill Method	No Holes	Total Meters	Anticipated Production	Time Required
WASSARA Combination Rig	83	31,400	175m/day ave	~6 months

Phase 2 Program- Windarra Upper G: 2 Year Reserve Delineation from 10175 Level

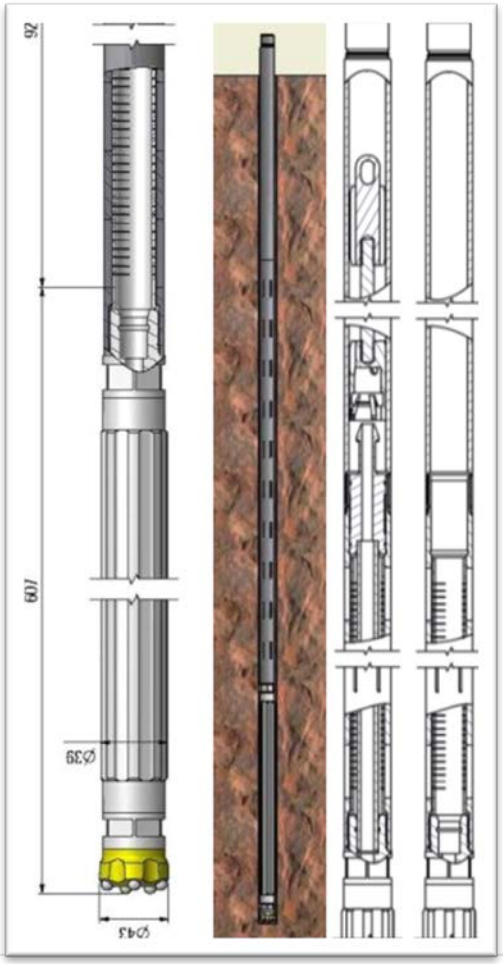
Drill Method	No Holes	Total Meters	Anticipated Production	Time Required
WASSARA Combination Rig	37	7,000	175m/day ave	~1.3 months

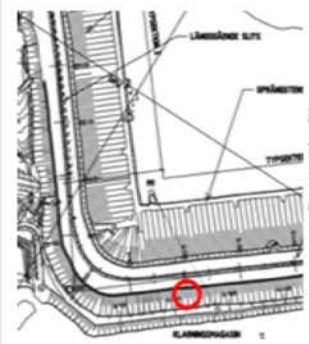
- Approx 3-6 months work initially pending favourable drill results and operational performance
- Initially ~31,000m of Wassara pre-collars then NQ2 drill core where possible (from drill cuddys on the 10050 level: See diagram below). BQ rods to be carried for drill through

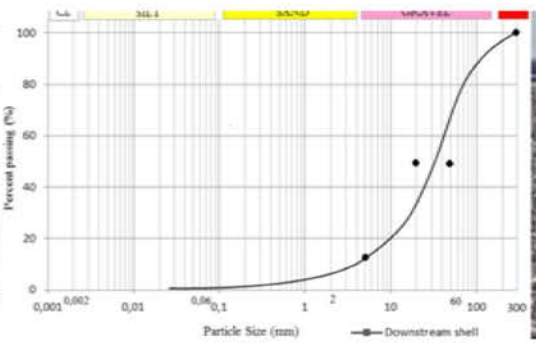
Wassara Projects

– Dam Instrumentation - New W35 Hammer

- *Project*: Comparison between Wassara and hydraulic top hammer technology for instrumentation setting in sensitive environment. (
- *Results:* Wassara was 10-15 faster (Drilling&Handling) than traditional methods and similar effect on the surrounding formation but with smaller Ø 42 v.s 102mm
- *Next Steps*: Instrumentation setting at LKAB Kiruna&Malmberget Q2/Q3 - 2013
- *Potential*: +48.000 Large dams world wide + industrial / mining dams







R&D

New Drills

Atlas Copco W6

- W70 – W120

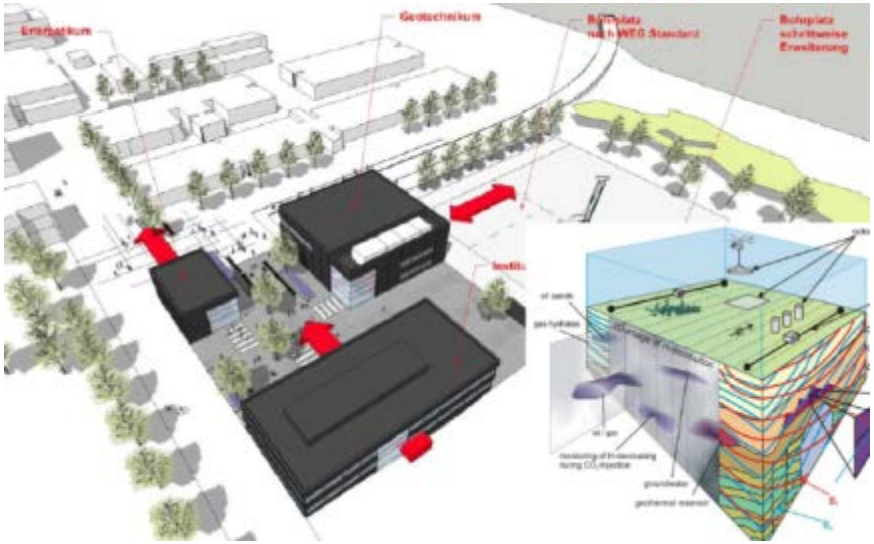
Ripamonti Birdie 200

- W35 - W50

WASC Recycling unit

Collaboration with Bochum Technical University

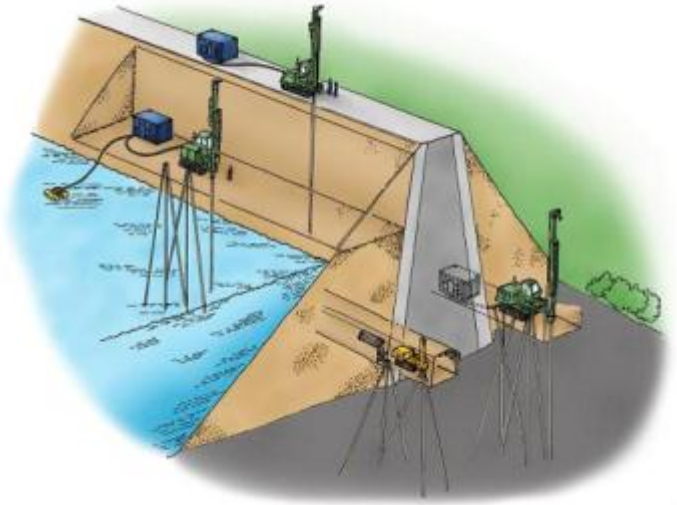
- The International Geothermal Association (IGA) will operate its secretariat from 1.1.2011 in Bochum, Germany



Instrumentation of embankments

• Drill down and leave the hammer in the ground. Use the drill tube as water level pipe.

•Fast (Single step)
•Small drill rig
•Logging wile drilling down
•Small hammer gives lower water flow
•Small hole disturbs less

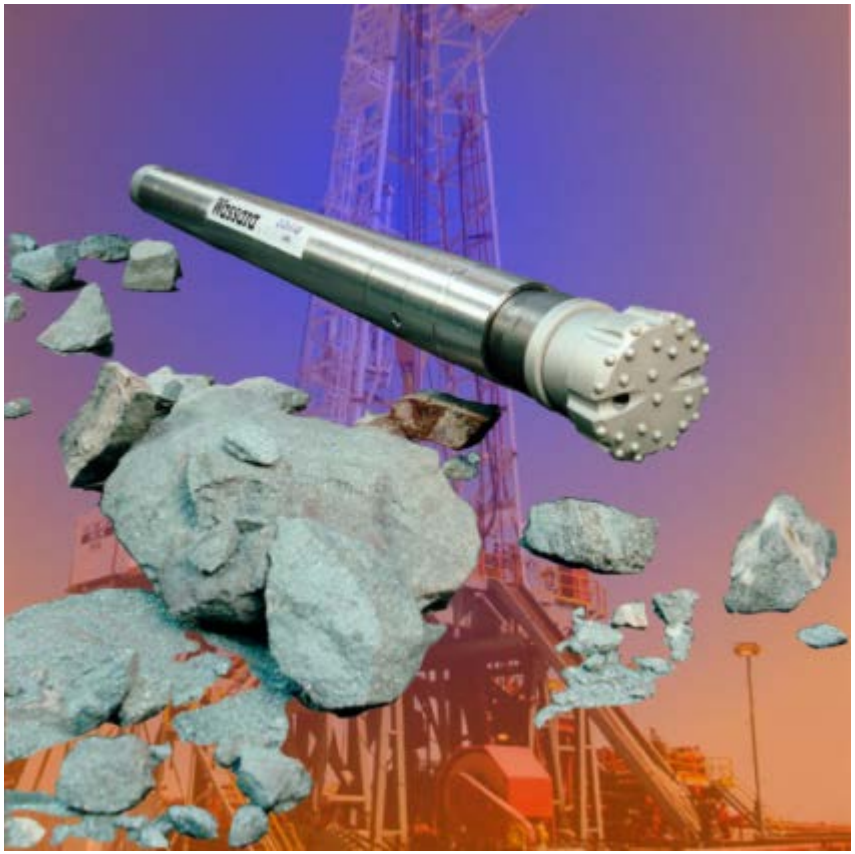


New Hammers

- W35 (drills ∅42mm holes)
- W150 180bar
- W200
- W100F1 – New hammer principle
  - 30% more output power
  - Heavier piston
  - Larger striking area

Patented

Mud Hammer for Deep Hole Drilling



- 10 years of development with >30 lab and down hole field tests (1996 – 2006)
- Restart 2011 - Percussion program with European Oil & Gas Company

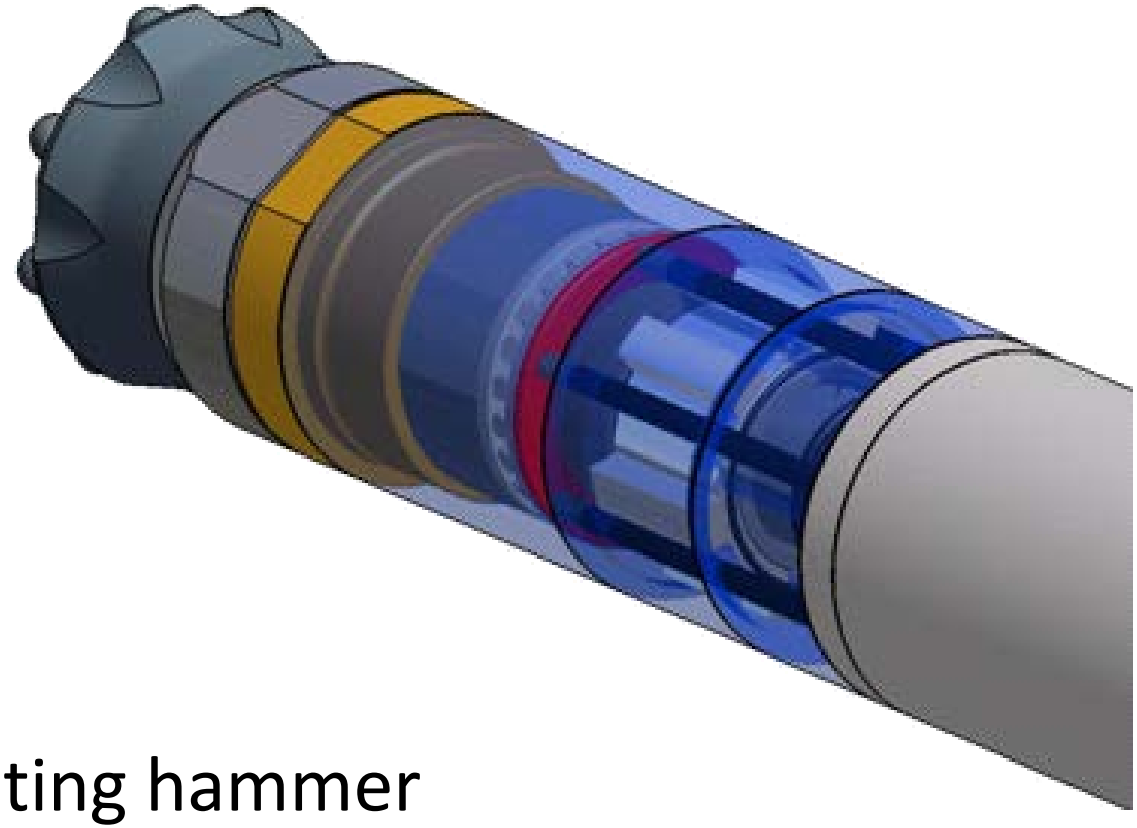
Wassara Exploration System 2.0

Remote drill site

W70 mud hammer

- Tolerates dirty water
- Makes it possible to reuse / recycle the drilling fluid

Index hammer

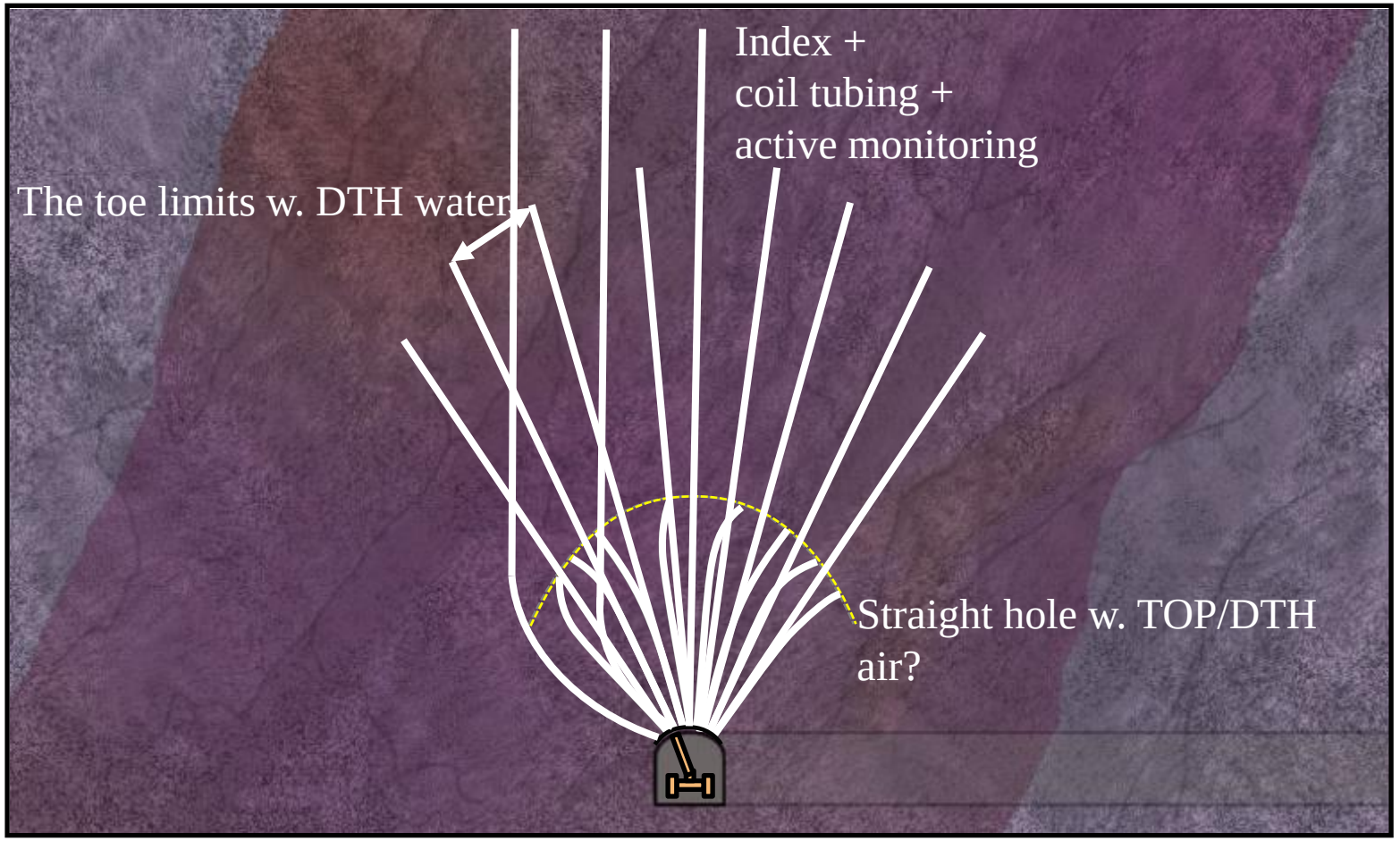


“Self” rotating hammer

Index hammer

+ coil tubing + monitoring + active steering

Production Drilling in the future!



Thank You!