HERRENKNECHT MINING

FULL SPECTRUM OF MINING SOLUTIONS

HERRENKNECHT

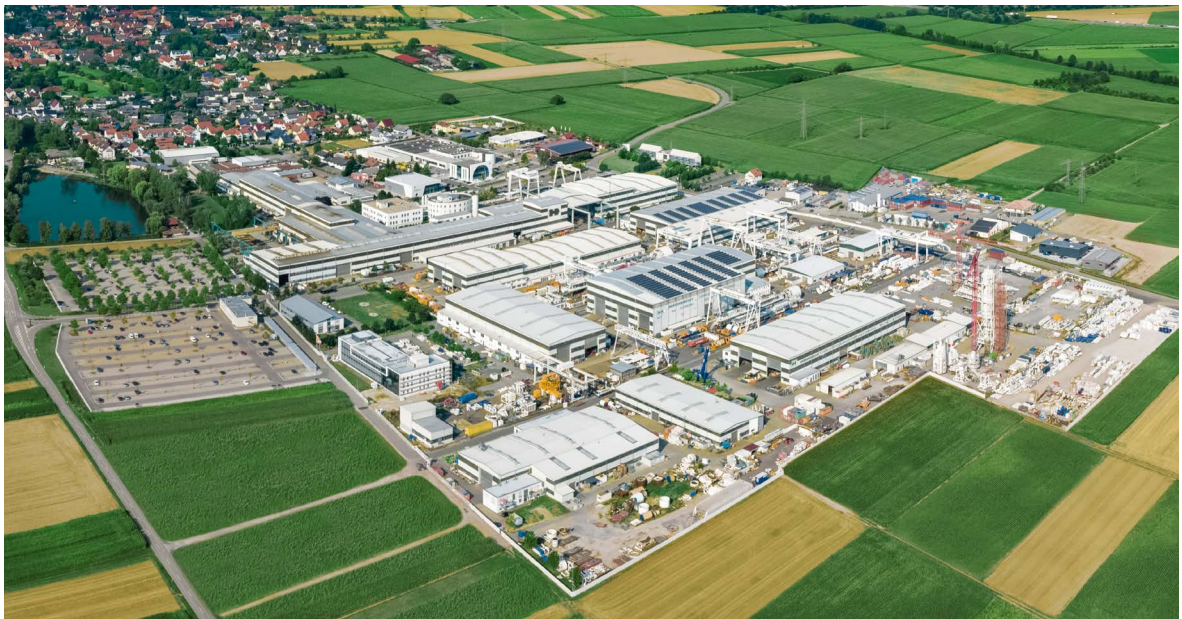
Tunnelling Systems

Pioneering Underground Technologies

For more than 40 years, Herrenknecht has been engaged in the tunnelling business and is the global market leader providing innovative and customized tunnelling technology for diameters of 0.1 to 19 meters. Furthermore, Herrenknecht provides technical solutions for successfully excavating inclined shafts and sinking vertical shafts down to great depths. Herrenknecht's references include more than 4,100 completed projects around the world with the support of more than 5,000 employees worldwide.

Based on its proven experience, Herrenknecht now provides an entire range of innovative machines for the mechanized construction of underground mining infrastructure. Whether for vertical access or production shafts, inclined vehicle access ramps, ventilation shafts or transport tunnels, Herrenknecht mining technology is designed for diameters of 0.3 to 12 meters and can reach depths of up to 2,000 meters. Our innovative solutions are based on proven technology that can achieve high advance rates and occupational health and safety using compact construction designs which have already proven their value in reference projects.

At Herrenknecht we see ourselves as technical pioneers in underground construction and in the future we will continue to develop new ideas together with our clients and contractors to make the development of mining infrastructure even safer and more efficient.



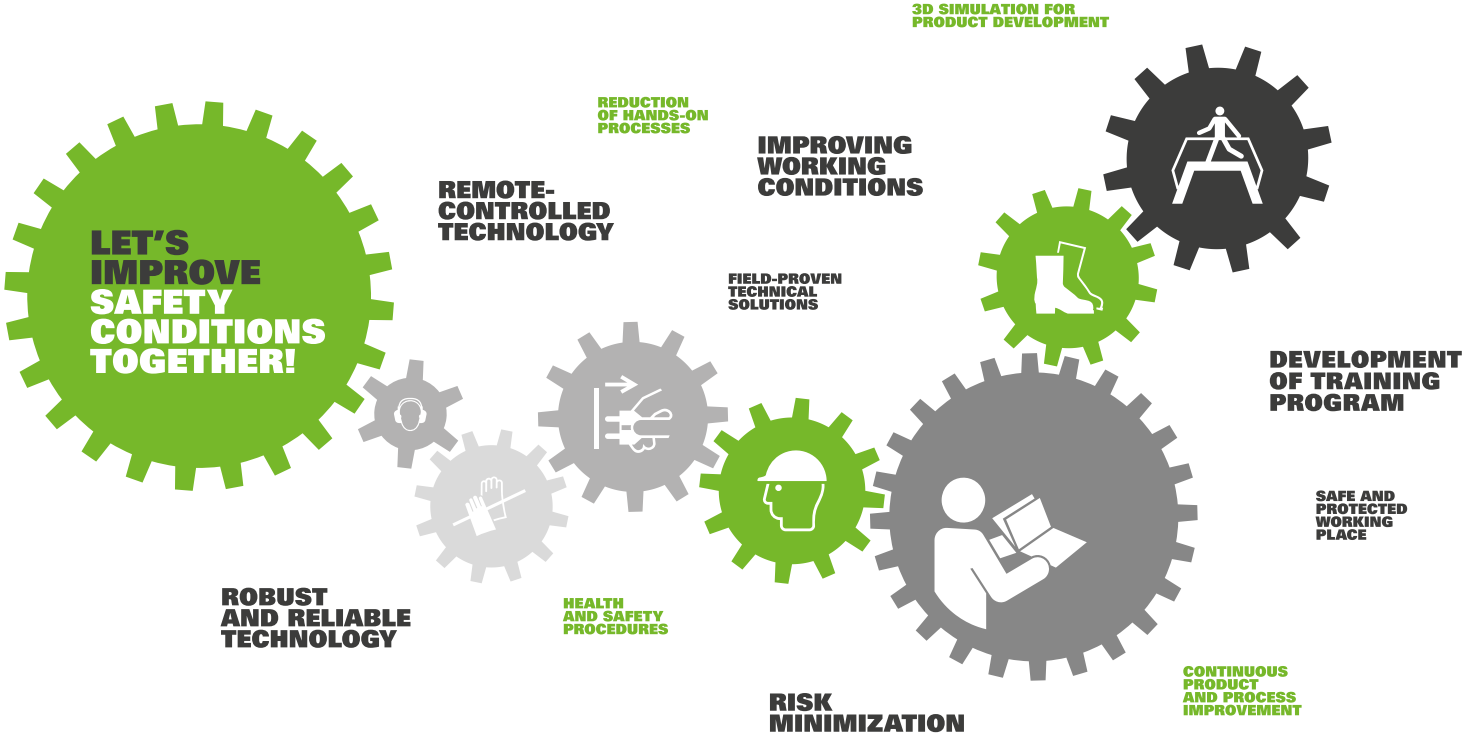
Headquarters in Germany, active worldwide. With more than 4,100 project references, we are a market leader all around the globe.

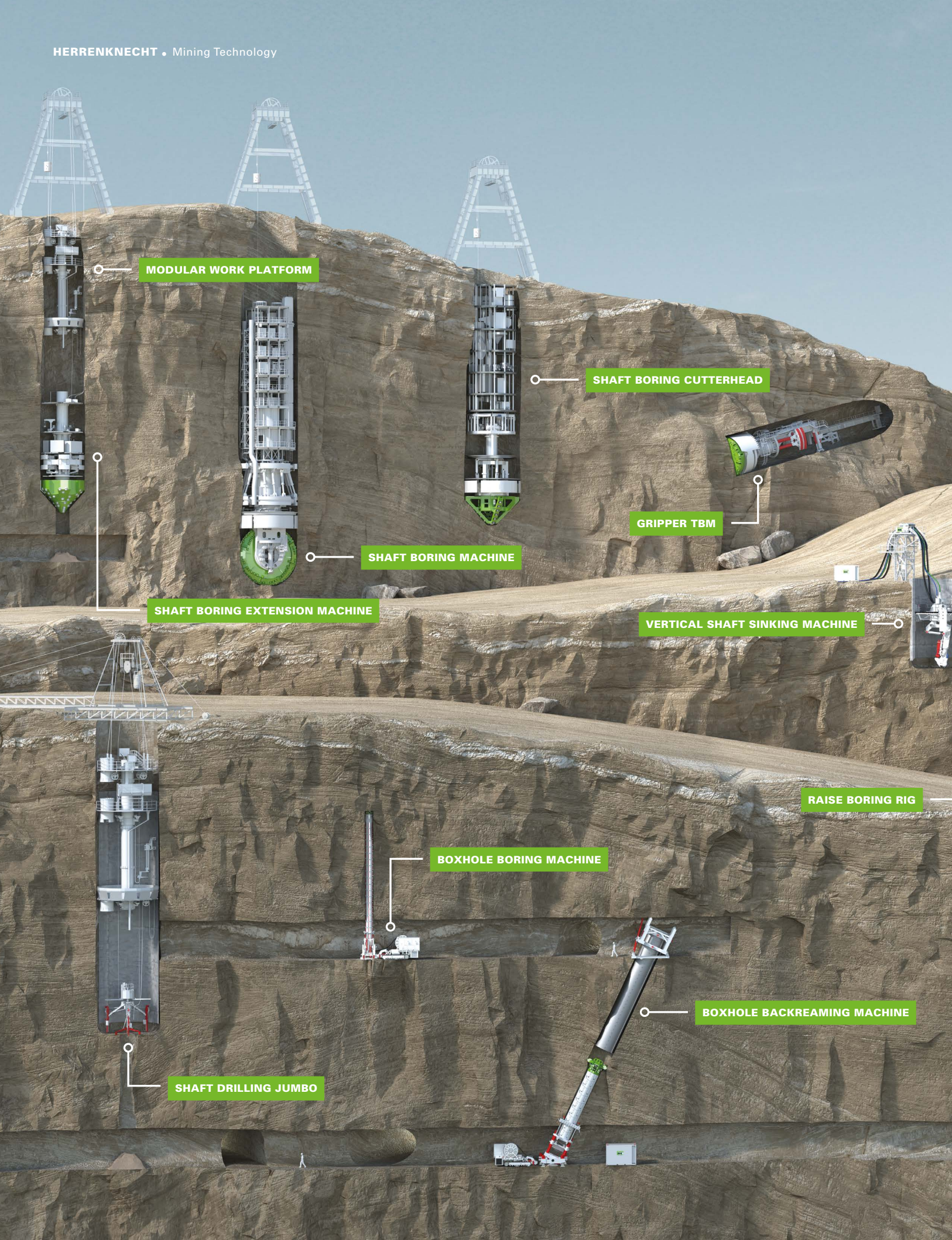
Herrenknecht
Safety Underground

The health and safety of every employee are essential prerequisites for all activities in the challenging work underground. As a premium supplier, Herrenknecht sets the highest standards in terms of health protection, occupational safety and quality.

The use of innovative technology in mining eliminates the need for explosives and leads to reduced manual processes during the development of mine infrastructure and production. We optimize our products through 3D-based safety management in the design process and we increase work safety through remotely controlled work operations.

As a result, Herrenknecht delivers tailor-made products securing the essential specifications for a safe and protected working place which also decreases environmental impacts. Moreover, together with mine owners and mine contractors we achieve production targets in a safe and cost efficient manner.




MODULAR WORK PLATFORM
SHAFT BORING CUTTERHEAD
GRIPPER TBM
SHAFT BORING MACHINE
SHAFT BORING EXTENSION MACHINE
VERTICAL SHAFT SINKING MACHINE
RAISE BORING RIG
BOXHOLE BORING MACHINE
BOXHOLE BACKREAMING MACHINE
SHAFT DRILLING JUMBO


SHAFT BORING ROADHEADER
H+E LOGISTIK VERTICAL CONVEYOR
GRIPPER TBM / VMT NAVIGATION AND MONITORING SYSTEM
TMS MULTI-SERVICE VEHICLE
REAMING HEADS AND CUTTING TOOLS
REEF BORING MACHINE

Mechanized Shaft Sinking Systems

Highest precision under toughest conditions

Herrenknecht shaft boring systems stand for innovative machine concepts that reach deposits at great depths of up to 2,000 meters safely and efficiently. They thus meet all requirements of the modern mining industry: short construction times for deep shafts with maximum safety. Thanks to simultaneous process steps, our mechanized systems can achieve high shaft sinking speeds and at the same time considerably improve work safety in mines. Shaft wall over-excavation is drastically reduced compared to conventional methods. All common lining methods can be used for securing the shaft wall. The mucking system can be selected according to the project requirements: pneumatic, slurry or mechanical mucking as well as muck haulage to a lower level through a pilot hole are possible.

SHAFT BORING ROADHEADER – SBR

EXCAVATION DIAMETER

EXCAVATION DEPTH

1,000 m – 1,500 m

GEOLOGY

Rock, soft to medium-hard consolidated rock

ADVANTAGES

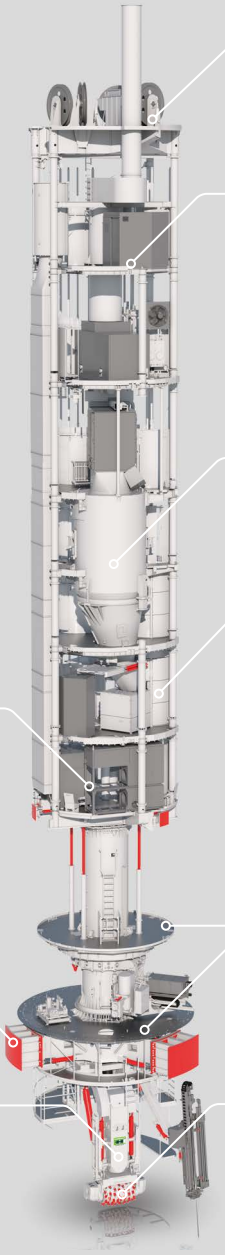
High level of work safety through remote controlled operation from the higher work decks

Higher sinking speed

Parallelization of the work steps

Variably adaptable to different shaft diameters, shaft geometries and lining methods

Adaptation of proven technologies such as the cutting drum and material transport system of existing systems



SHEAVES DECK
SBR suspended by shaft ropes, can be lifted or lowered as required

WORK DECKS
Several decks with installations, infrastructure and supply line extensions for power, air and ventilation

PNEUMATIC MUCKING SYSTEM
Demucking method cleans bench and collects cuttings in suction tank

MUCK BUCKET
The muck is hoisted to the surface. Auxiliary and man buckets are also used

CONTROL CABIN
The SBR operator controls all functions and the semi-automatic excavation process

ROCK SUPPORT DECK
Several applications can be installed: shotcrete, rock bolts, mesh, segments or liner plates

STABILIZER
Transfers cutting forces to the shaft wall. Adaptable to different diameters

EXCAVATION CHAMBER
Man access only for maintenance. Installation of segments or shotcrete possible as well

ROADHEADER
Excavation unit can cut different diameters and shaft recesses as required

SHAFT BORING MACHINE – SBM

EXCAVATION DIAMETER

10 m 12 m

EXCAVATION DEPTH

> 2,000 m

GEOLOGY

Rock, hard rock

ADVANTAGES

Robust design for high sinking performance

Secure grip due to self-bracing gripper system

Significant improvement in work safety and reduced dust and noise pollution for personnel

CONTROL CABIN
The SBM operator controls all functions and the semi-automatic excavation process

GRIPPER
Supports the machine weight and provides reaction for the cutting forces

MAIN DRIVE
Propels the cutting wheel and turns 180° around the vertical axis

EXCAVATION CHAMBER
Un-manned during standard operation

WORK DECKS
Several decks with installations, infrastructure and supply line extension for power, air and ventilation

MECHANICAL MUCKING SYSTEM
Transports the cuttings to the muck-handover point with vertical conveyor belts

ROCK SUPPORT DECK
Several applications can be installed: shotcrete, bolts and mesh to support the shaft wall as primary lining

CUTTERHEAD
Similar to a TBM the rock is cut by disc cutters and collected in bucket channels

SHAFT BORING CUTTERHEAD – SBC

EXCAVATION DIAMETER

8 m 9 m

EXCAVATION DEPTH

1,000 m

GEOLOGY

Rock, hard rock

ADVANTAGES

Parallelization of work steps

Increased sinking speed

High level of work safety

No impairment of the surrounding geology

Flexibility in the shaft lining method

Safe operation even with high water ingress

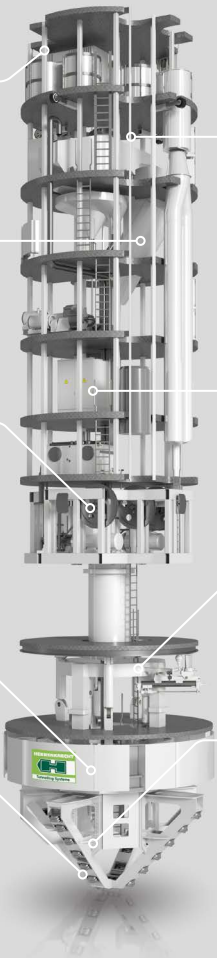
MUCK BUCKET
The muck is hoisted to the surface. Auxiliary and man buckets are also used

SLURRY MUCKING SYSTEM
Use of submersible pumps to lift the cuttings to a de-sander. Bigger chips are hoisted to the surface

SHEAVES DECK
SBC is suspended by shaft ropes and can be lifted or lowered as required

GRIPPER
Creates additional thrust force for the cutterhead and steers the cutterhead according to the guidance system

EXCAVATION CHAMBER
When using the slurry mucking method the bench is flooded and can be used as a sump for water ingress



WORK DECKS
The dewatering units, slurry and feed lines are located and extended from the decks, same as installation, infrastructure and supply line extensions for power, air and ventilation

CONTROL CABIN
The SBC operator controls all functions and the semi-automatic excavation process

ROCK SUPPORT DECK
Several applications can be installed: shotcrete, rock bolts, mesh, segments or liner plates

CUTTERHEAD
Equipped with cutting discs and can be adapted to different diameters

SHAFT BORING EXTENSION MACHINE – SBE

EXCAVATION DIAMETER

EXCAVATION DEPTH

>2,000 m

GEOLOGY

Rock, hard rock

ADVANTAGES

Parallelization of work steps

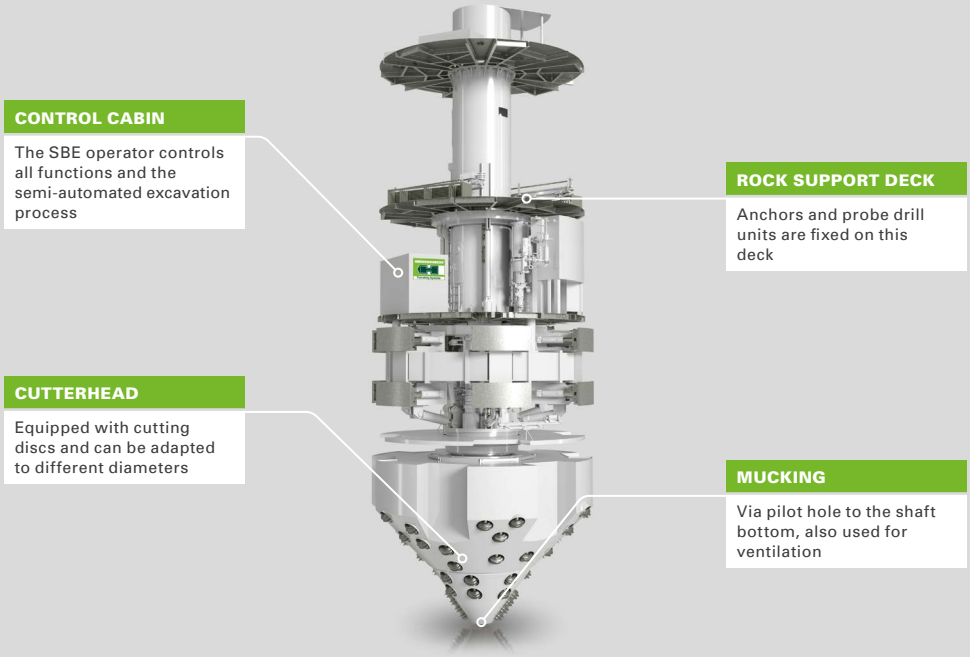
Increased sinking speed

High level of work safety

No impairment of the surrounding geology

Flexibility in the shaft lining method

Safe operation even with high water ingress



SHAFT DRILLING JUMBO – SDJ

DIAMETER

DEPTH

>2,000 m

GEOLOGY

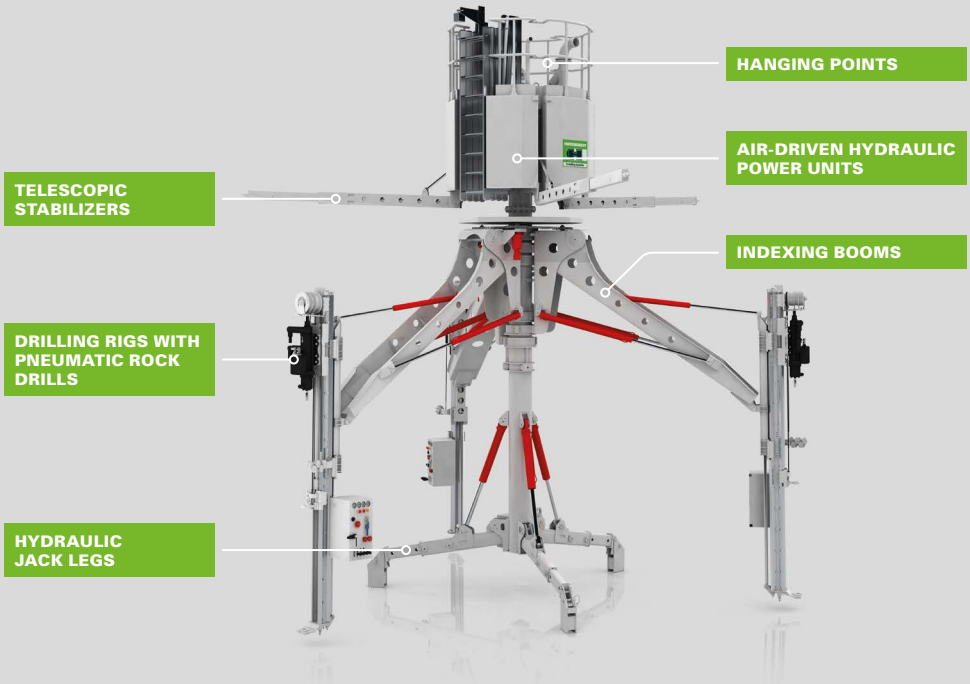
Rock, medium-hard to hard rock

ADVANTAGES

Suitable for blind shaft construction and shaft enlargement

Applicable in mining and underground construction

Fast and precise shaft construction



VERTICAL SHAFT SINKING MACHINE – VSM

EXCAVATION DIAMETER

EXCAVATION DEPTH

Up to 150 m

GEOLOGY

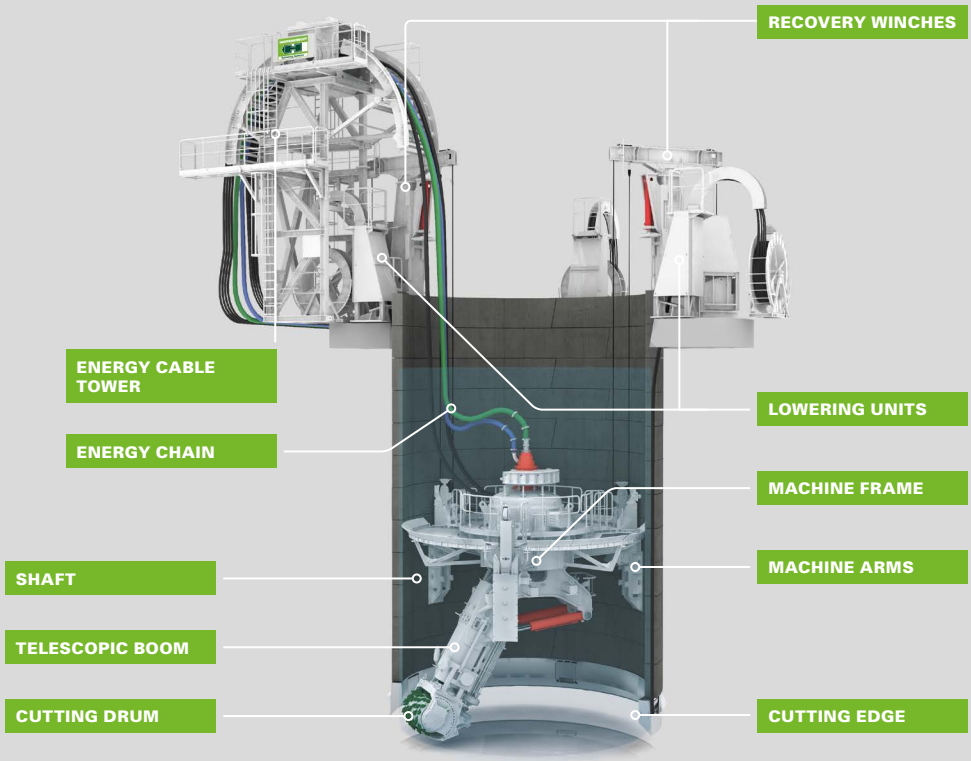
Soft ground, heterogeneous ground, rock

ADVANTAGES

For soft and heterogeneous ground up to 80 MPa and below groundwater

High advance rates of up to 5 m per shift due to parallel work processes

Flexible arrangement of the machine equipment enables use even under tight space constraints



SPECIAL SHAFT SINKING MODULES

Specific applications based on proven technology

Herrenknecht provides drilling equipment and tubbing segment handling devices for TBMs all over the world. This experience is used to modify the known technologies into tailor-made solutions for special shaft sinking applications.

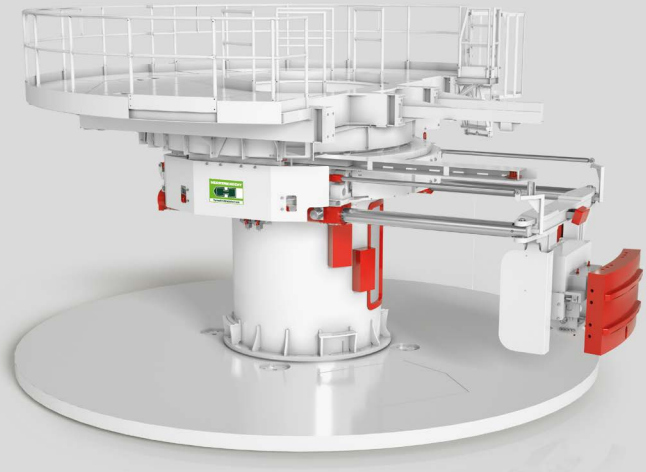
The Herrenknecht Ring Erector is able to handle liner plates, pre-cast concrete or steel segments as an integrated solution or stand-alone unit.

MACHINE DATA

Ring Erector

- Operation in shaft diameter of 6 m – 12 m
- Can handle tubbing segments with mechanical gripping system
- Remote-controlled system
- Integrated safety interlocks and assistance systems
- Alignment via laser target system

Can be equipped with several tools (small drilling rig, mesh handling tool, rock bolting unit, cutting drum, shotcrete robot) to suit special applications.



Powerful Shaft Boring

High performance Raise Boring Rigs

With the long-proven Raise Boring technology a broad variety of shafts in mining and civil projects can be drilled. This allows very fast and competitive construction of shafts with different diameters for various applications such as ventilation, hoisting, pressure shafts and ore passes. Even for shafts with the hardest rock the Herrenknecht Raise Boring Rigs with their highly efficient variable frequency drives have the torque and thrust capacities needed. High performance and occupational health and safety have been core values in the design of the machine. Thanks to its compact and modular design, it can be shipped easily worldwide and delivers reliable operation wherever it is needed. In addition, customized solutions can be offered to adapt to special applications, increase automation and improve efficiency. With a wide portfolio of additional equipment, we can supply a complete Raise Boring system matching your needs and project requirements.

RAISE BORING RIG – RBR

EXCAVATION DIAMETER

EXCAVATION DEPTH

Up to 2,000 m

GEOLOGY

Rock

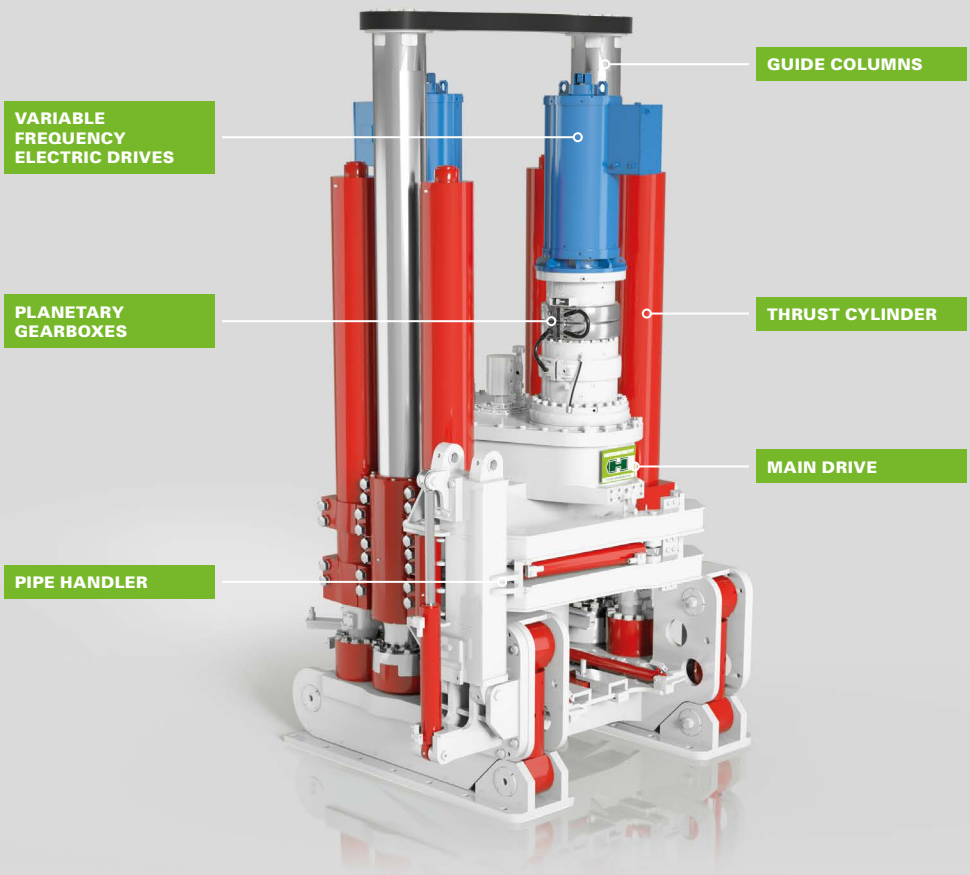
ADVANTAGES

For long raises and large reaming diameters

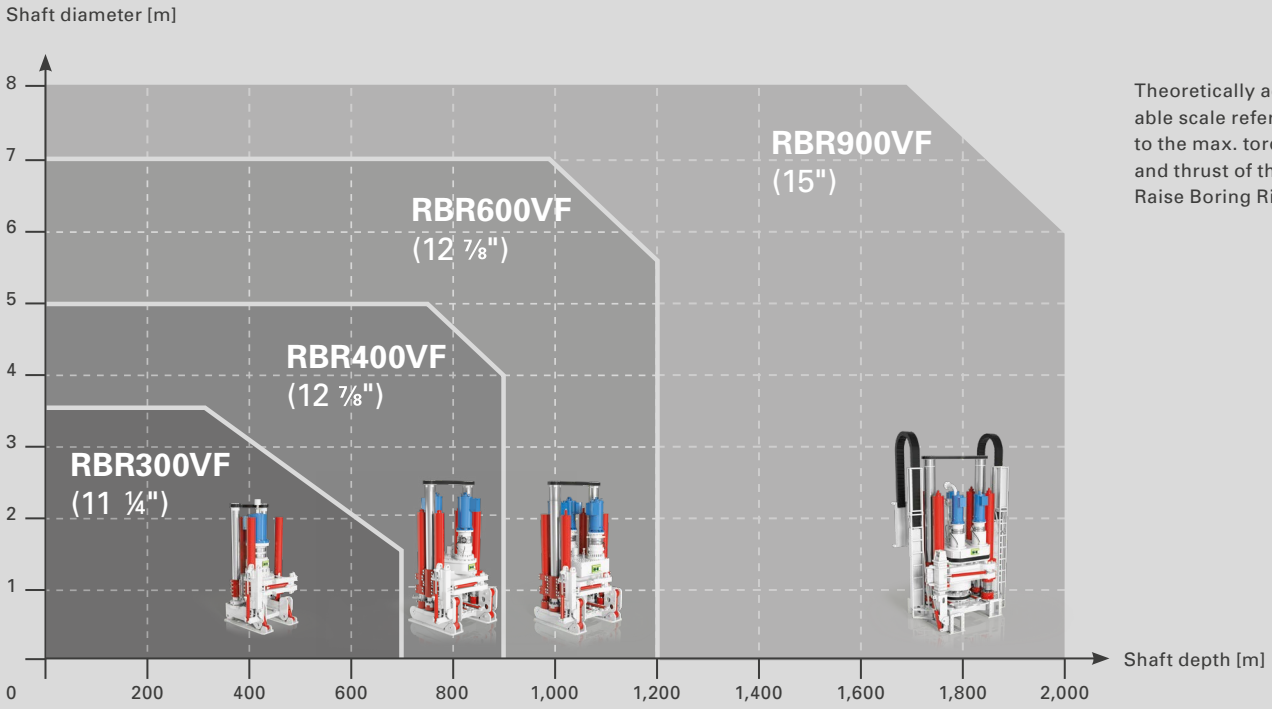
Robust and powerful design

Mechanized wrench system and rod handling for improved work safety

Highly efficient variable frequency drive



RAISE BORING CAPABILITIES



Theoretically achievable scale referring to the max. torque and thrust of the Raise Boring Rigs.

Reaming Heads and Cutting Tools

Herrenknecht offers a wide portfolio of additional equipment. The newly developed reaming heads and cutting tools supply a complete raise boring system, matching diverse project requirements such as variable diameters or customized design. The unique remote monitoring of the reaming heads' raise boring cutters and stems as well as the cutters' changeable bearings increases the efficiency and therefore reduces costs.

ADVANTAGES

Raise Cutter Monitoring
Rotational and temperature monitoring to detect worn cutters in real time and to optimize the maintenance intervals

Stem Monitoring
Load monitoring of the reaming head's stem to prevent overloading in difficult ground conditions

Increased bearing capacity and cutter lifetime

Changeable bearings allow cutter refurbishment

Customized solutions: special diameters, fractured ground, horizontal raise boring

Wide range of modular reamers from 1 to 8 meters.

Mobile Boxhole and Reef Boring Machines

Rapid and safe drilling of small diameter shafts

Herrenknecht has developed customized state of the art mining machines for the excavation of vertical and inclined slot holes and shafts in hard rock for a wide range of underground applications. The design of the Herrenknecht mining machines focuses on high productivity, optimal mobility and minimal space requirements as well as improved occupational health and safety through remote control.

The Reef and Boxhole Boring Machines' concept is based on the proven pipe jacking technology that has been adapted for upward vertical and inclined excavation. They do not require any concrete slabs or special preparatory work before excavation begins, saving time and costs. The Boxhole Backreaming Machine offers shaft lining simultaneous to the remaining process.

For their relocation, remote-controlled crawler units make the Herrenknecht machines independent of other operations in the mine. The modular design enables high flexibility with time and space-saving setup in a confined environment.

BOXHOLE BACKREAMING MACHINE – BBR

EXCAVATION DIAMETER

EXCAVATION LENGTH

Up to 70 m

GEOLOGY

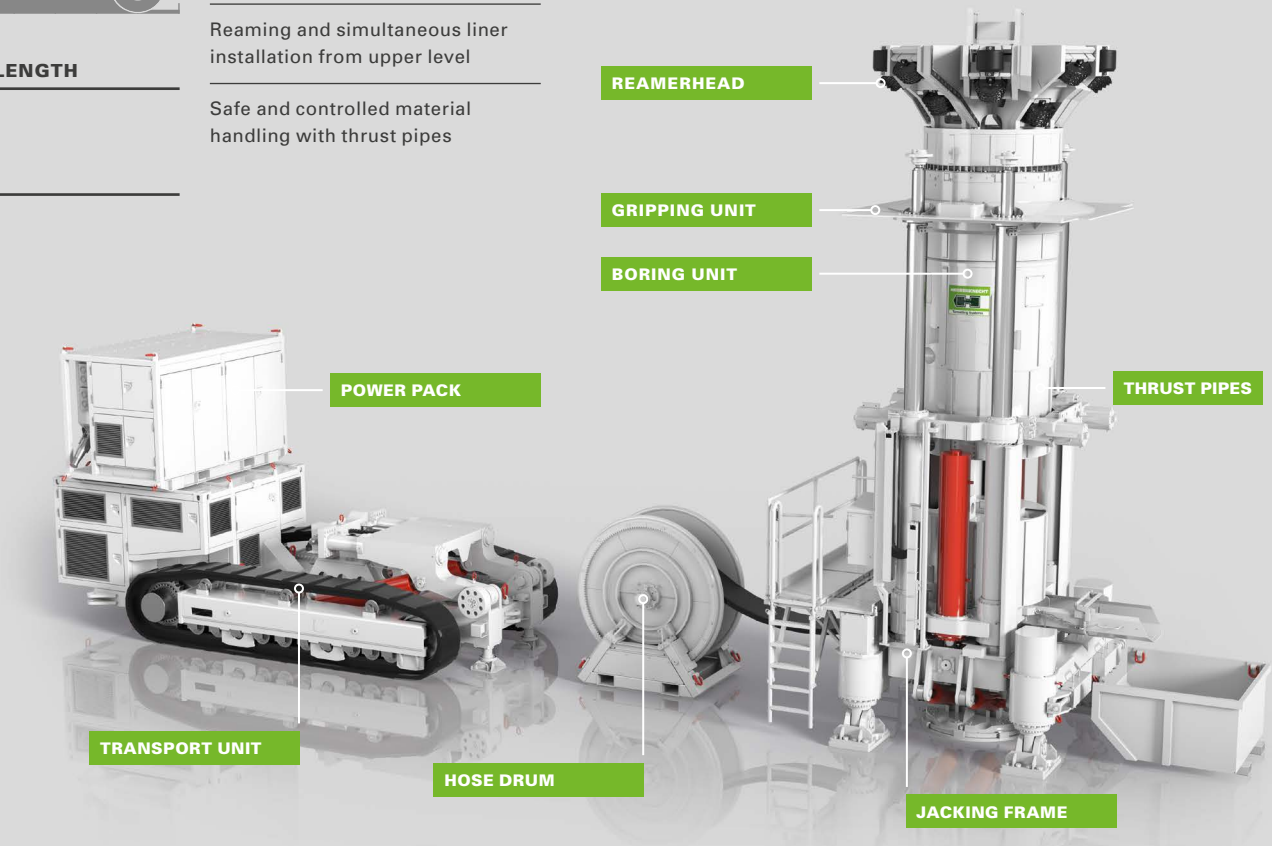
Rock

ADVANTAGES

Based on proven BBM method with increased diameter range

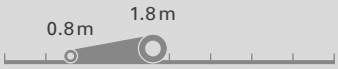
Reaming and simultaneous liner installation from upper level

Safe and controlled material handling with thrust pipes



BOXHOLE BORING MACHINE – BBM

EXCAVATION DIAMETER



EXCAVATION LENGTH

Up to 70 m

GEOLOGY

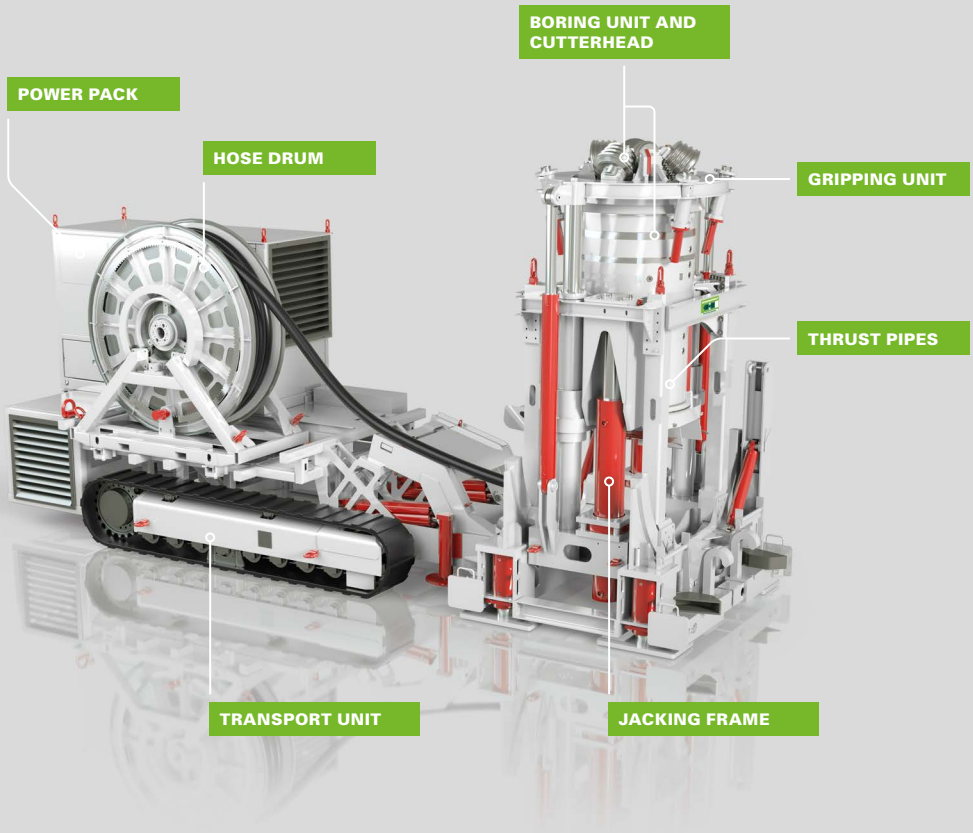
Rock

ADVANTAGES

Designed for stable rock up to 300 MPa

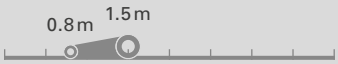
Compact, modular design for use under space constraints

High occupational safety thanks to remote-controlled operation



REEF BORING MACHINE – RBM

EXCAVATION DIAMETER



EXCAVATION LENGTH

Up to 40 m

GEOLOGY

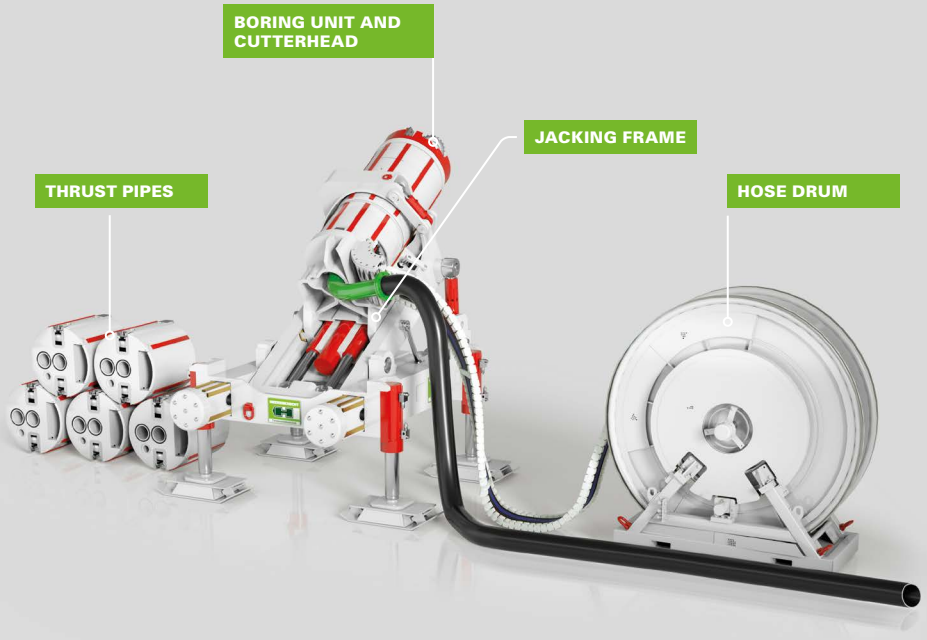
Rock

ADVANTAGES

Mechanized reef miner offers high safety and productivity and continuous operation

RBM method allows accurate steered drilling minimizing dilution

Material handling with pneumatic suction unit reducing water consumption and losses



JANSEN MINE, CANADA

- **Machine:** 2 Shaft Boring Roadheaders
- **Excavation depth:** 1,000 m
- **Diameter:** 8 m – 11 m
- **Geology:** heterogeneous ground, rock
- **Contractor:** DMC Mining Services
- **Project owner:** BHP Billiton Ltd.

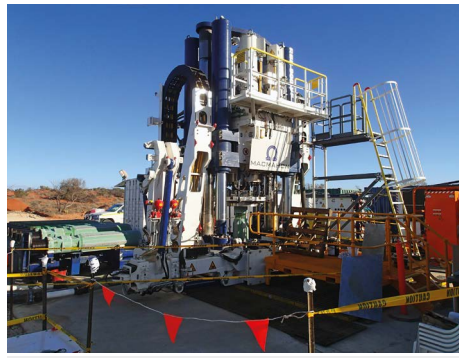
Potash mining at a depth of 1,000 meters

The tiny village of Jansen and the largest potash deposits on earth are located in Saskatchewan, Canada.

The Australian mining company BHP Billiton Ltd. expects to mine up to eight million tons of potash ore annually in Jansen. The mine will be equipped with the most innovative mining technologies.

DMC Mining Services was sinking deep vertical shafts in soft medium rock with depths of up to 1,000 meters and with diameters of 8 to 11 meters with two Herrenknecht Shaft Boring Roadheaders (SBR). The rock was excavated using the partial-face method, with a cutting drum located on a telescopic boom, adapted from the proven Herrenknecht VSM technology for Shaft Sinking Machines, and conveyed via an innovative pneumatic mucking system.

The roadheader is remote-controlled from the work decks, allowing safe working conditions. Mechanized shaft sinking aims to achieve higher efficiency which is important for the cost-effective exploitation of potash. This system has proven flexibility and adaptation to special requirements of the project. In August 2018, a milestone in the mining industry has been reached with the successful completion of the two shafts to depths of -975 and -1,005 meters respectively.



OLYMPIC DAM, AUSTRALIA

- **Machine:** Raise Boring Rig
- **Excavation depth:** 730 m
- **Diameter:** 4.5 m
- **Geology:** rock > 120 MPa
- **Contractor:** Macmahon
- **Project owner:** BHP Billiton Ltd.

Fast construction of deep hard rock shafts

The world's most powerful Raise Boring Rig, the RBR900VF manufactured by Herrenknecht, is in operation at BHP Billiton's Olympic Dam mine in South Australia. The powerful rig is employed for the construction of 730 meter deep ventilation shafts in hard rock. Thanks to its design, the remote-controlled system with the newly developed pipe feeder ensures both efficient workflows as well as significantly greater work safety for the personnel during installation and removal of the drill string.

Customer quote from Macmahon: "The design of the new raise drill has eliminated most of the manual lifting, pushing and manoeuvring efforts required by operators. This is a major step forward that will not only boost safety but also increase productivity." The machine is designed for long raises up to 2,000 meters and large reaming diameters for ventilation and haulage shafts. The robust and powerful rig with its highly efficient variable frequency drive ensures reliable operation in various conditions.

NANT DE DRANCE, SWITZERLAND

- **Machine:** Raise Boring Rig, Shaft Drilling Jumbo, Gripper TBM
- **Excavation depth:** 424 m
- **Diameter:** 2.44 m – 9.45 m
- **Geology:** rock > 120 MPa
- **Contractor:** Marti Tunnelbau AG, Marti Contractors Ltd., Östu-Stettin Hoch- und Tiefbau GmbH
- **Project owner:** Alpiq, CFF, IWB, FMV

Underway in all directions

Where mechanized shaft sinking methods cannot be used, the Shaft Drilling Jumbo comes into its own. In this procedure, blast patterns with two to five rigs are created – either for blind shafts or shaft enlargement. The shaft is extended with each blast and the Jumbo is repositioned.

A fully proven technology at "Nant de Drance" power plant project in the Swiss canton of Valais. The power station will generate the energy from two reservoirs via pressure shafts to produce 900 megawatts. A Herrenknecht Gripper TBM excavated the 5.6 kilometer long access tunnel to the cavern of the pumped-storage power plant. The two RBR600VF Raise Boring Rigs are reaming two pre-shafts with a diameter of 2,44 meters. The Drilling Jumbo extended these two 424 meter-deep shafts to a diameter of 8 meters.

With its flexible and cost-effective technology, the "Jumbo" is an ideal extension to the existing Herrenknecht technologies.

LADY LORETTA MINE, AUSTRALIA

- **Machine:** Boxhole Boring Machine
- **Excavation depth:** up to 30 m
- **Diameter:** 1.1 m
- **Geology:** rock > 120 MPa
- **Contractor:** Mancala Holdings Pty Ltd.
- **Project owner:** Glencore Xstrata PLC

Record performance in Australian mines

The Herrenknecht Boxhole Boring Machine (BBM) is an example of how the technology transfer from tunnel construction to mining operations can take place. The BBM is based on the proven pipe jacking method and is used to drill vertical and inclined shafts with diameters of up to 1.5 meters.

The latest top performer in Australia is a second generation BBM 1100 in Glencore Xstrata's Lady Loretta mine with a contract of over 500 meters and 26 slot holes. At up to 3 meters per hour and up to 16 meters per shift, within just 4 weeks 11 slot holes were created with total output of over 200 meters.

Three BBMs from Herrenknecht have successfully completed upwards of 130 holes with a total output of more than 2,500 meters at different underground mines in Australia. The drilling diameter is 1.1 meters at maximum drilling lengths of up to 30 meters.

The remote-controlled BBM technology convinced our customers with high occupational health and safety, high mobility and a large spectrum of application ranges, such as ventilation shafts and slot holes for draw points (ore extraction points).

EL TENIENTE MINE, CHILE

- **Machine:** Boxhole Boring Machine
- **Excavation depth:** 1,000 m
- **Diameter:** 1.5 m
- **Geology:** rock > 120 MPa
- **Contractor:** Mas Errázuriz Ltda., Constructora Gardilcic Ltda.
- **Project owner:** BHP Billiton Ltd.

Rapid and precise through hard rock

In 2013 Herrenknecht supplied two BBM1500 for the drilling of ventilation shafts in the world's largest underground copper mine, El Teniente in the Chilean Andes at 2,000 meters above sea level.

The BBM1500 is a further development of the BBM1100 with a larger drilling diameter (1.5 m) and greater torque (115 kNm).

The BBM1500 is equipped with a navigation system in order to ensure accurate positioning of the hole. If necessary, the alignment of the boring unit in the borehole can be altered by means of hydraulic cylinders.

Under the direction and with support of the systems by service technicians from the Chile Herrenknecht subsidiary and two Chilean drilling companies, the two Boxhole Boring Machines have completed more than 30 slot holes and shafts with a total output of more than 1,200 meters in the first 12 months. The maximum distance excavated was 60 meters. Best performances of up to 2.7 meters per hour and 17 meters per day were achieved.

WARRIOR COAL MINE, USA

- **Machine:** Raise Boring Rig
- **Excavation depth:** 205 m
- **Diameter:** 6.7 m
- **Geology:** rock > 120 MPa
- **Contractor:** Frontier-Kemper Constructors
- **Project owner:** Warrior Coal, LLC

Large diameter Raise Boring Shaft

The US raise boring operator Frontier-Kemper ordered an RBR600VF from Herrenknecht, which proved itself in the 6.7 meter diameter access shaft for the Warrior Coal mine in Kentucky, USA. A Raise Boring Rig with its highly efficient variable frequency drive supplied the torque and thrust required for this challenging project. Customer support for the rig is provided by Herrenknecht Tunnelling Systems USA in Sumner, WA.

A world premiere is the system for remote maintenance of the rig with the "Digital Drilling Report", used here for the first time. Over a network connection it offers Frontier-Kemper the possibility of monitoring the drilling performance of the rig, its availability as well as any difficulties encountered during operation, in real time, from the jobsite office or from company headquarters. The system replaces the usual manual drilling report, simplifies evaluation and allows more reliable drilling data analyses that can be used for the optimization of future projects. The supplied integrated cooling unit ensures the operational readiness of the rig at outside temperatures up to 40° C.

Pioneering Underground Technologies

Herrenknecht is the world's leading premium supplier for technology solutions in mechanized tunnelling. Working closely with our customers, we can meet any challenges and together realize underground mining infrastructures of all kinds. Successfully and in top quality.

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