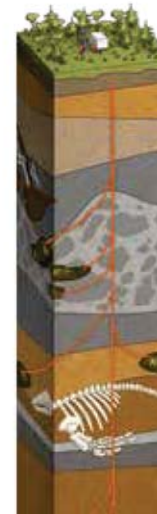


DIRECTIONAL CORING WHILE STEERING **CORE** **DRILLING**



**DEVICO DELIVERS
THE COMPLETE
SOLUTION TO YOUR
DRILLING PROGRAM**

- Borehole planning
- Improve core drilling accuracy
- Reduce drilling length
- Reduce environmental impact
- Reduce drilling time and cost



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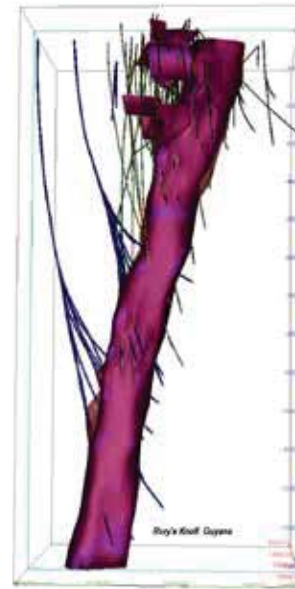


VISIT OUR WEBSITE FOR MORE INFORMATION:
www.devico.com

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Rock core sample with a distinct "Devico bend"



Branching of boreholes

DCD SERVICES

Devico DCD services consist of world leading directional core drilling equipment, highly professional field engineers and a strong knowledge base. For every project Devico will deliver:

- Free borehole planning before start-up and during drilling
- Free savings analysis for each target
- Control over natural deviation
- Target intercepts within 1 % error
- Branching of boreholes to reduce amount of drilling
- Daily reports and plotts of borehole progress
- Field technicians controlling the DCD, ensuring high quality results.
- Strong focus on on-site collaboration and efficient operation
- Assistance in monitoring core orientation and surveying boreholes

DEVICO AS

Devico has more than 20 years of experience with directional core drilling (DCD) and borehole surveying. The company has developed a range of top quality instruments including directional core barrel, core orientation equipment and both magnetic and non-magnetic downhole survey instruments. The product line ensures coring targets are reached successfully while the drilling costs are reduced. Today, the company is the market leader internationally in providing directional coring services directly or via its network of exclusive agents and subsidiaries.

To provide top qualified DCD services to the drilling industry Devico and its subsidiaries have established an international group of expert field engineers that supervise directional projects around the globe. Our engineers are highly educated and have been through an extensive training period of one year or more to earn their title. On DCD projects they work together with the drilling contractor to secure that the operation runs smoothly and efficiently.

The engineers also work with the project geologists to prepare and optimize drilling plans. They will suggest the depth where directional drilling should be started, and calculate the length of steering necessary to aim the hole towards the target.



Field engineer

PLANNING SERVICES

To investigate the benefit of directional drilling in a specific drilling program Devico will, free of charge, provide a drilling plan to potential clients. The plan will estimate the total amount of standard and directional drilling required, and the meters saved compared to drilling all targets from surface. Inclination and azimuth at target intercept will also be provided.

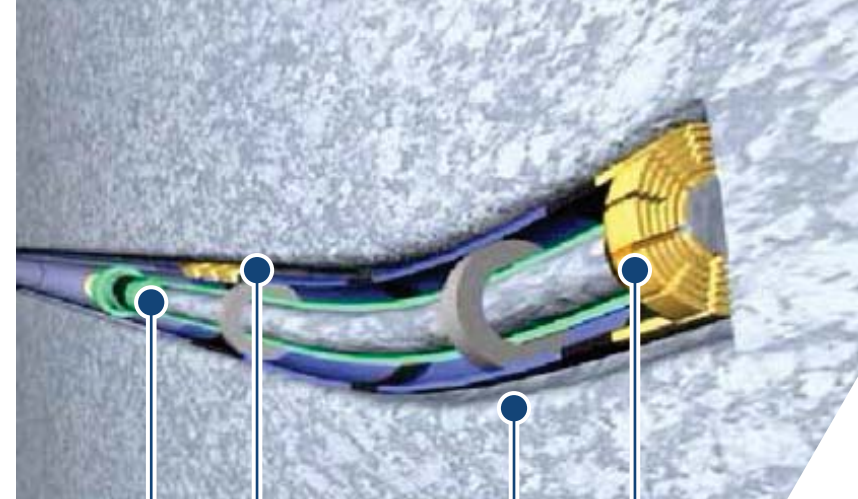
The plans will be based on standard N-size wireline down to the proposed kick-off point, where DCD is initiated. DCD is performed until the borehole is aiming towards the final target, and then finalized with standard wireline core drilling.

When the first target is reached, the hole ("mother hole") is sidetracked and the branch hole aimed towards a second target. There are no limits on how many sidetracks can be made, but 5 to 10 branch holes are the most common.

TYPICAL DRILLING PLAN WITH ESTIMATED SAVING

Directional Drilling					End of Hole (m)	Standard Core Drilling (m)
Toolface (deg)	Dogleg (deg/30m)	Azi (End)	Dip (End)	Dist. DCD (m)		
298	9	327	-66	34	790	754
321	9	312	-56	41	738	220
18	9	329	-48	65	694	138
310	9	310	-49	96	680	314
311	9	311	-37	61	628	222

Total with DCD:	1946
Total with only standard core drilling:	3530
Saved meters:	1584
Total DCD:	297



Core sample is taken during the steering process

DEVIDRILL

Directional core drilling (DCD) is done with the DeviDrill directional core barrel. The principle behind the DeviDrill is a drive shaft running through a bushing offset from the center line of the tool. Expanding pads operated by differential pressure keep the DeviDrill in a fixed orientation while drilling in a curve.

The inner assembly carries an inner tube collecting the core, a muleshoe system, and an instrument barrel with the survey tool recording inclination and orientation.

Orientation data is stored inside the survey tool and made available to the field engineers after each run.

Specifications	
Bit diameter	75.4 mm/2.97" (N-size)
Reamer diameter	75.6 mm/2.98"
Core diameter	31.5 mm/1.24"
Core length	3 m/10 ft

START PACKAGE

When a DCD project is ordered, a start package is sent to the project site. The Devico field engineer will there assemble the equipment and prepare it for operation. One start package is enough to cover work on up to 3 drill rigs by moving between them whenever a directional correction is necessary. When not in use, the equipment is maintained and kept in a secure container near the field operation.



THE PACKAGE INCLUDES:

- DeviDrill core barrel
- Borehole survey instrument
- Orientation instrument
- Spare parts
- Tools



The start package should be kept in a secure container, which can also be used as a workshop for the Devico engineers.

DOGLEG

Dogleg describes the average curvature of the borehole expressed as degrees deviated over a distance of 30 meter. Directional drilling may deviate the borehole with up to a dogleg of 12, depending on the drill string in use.

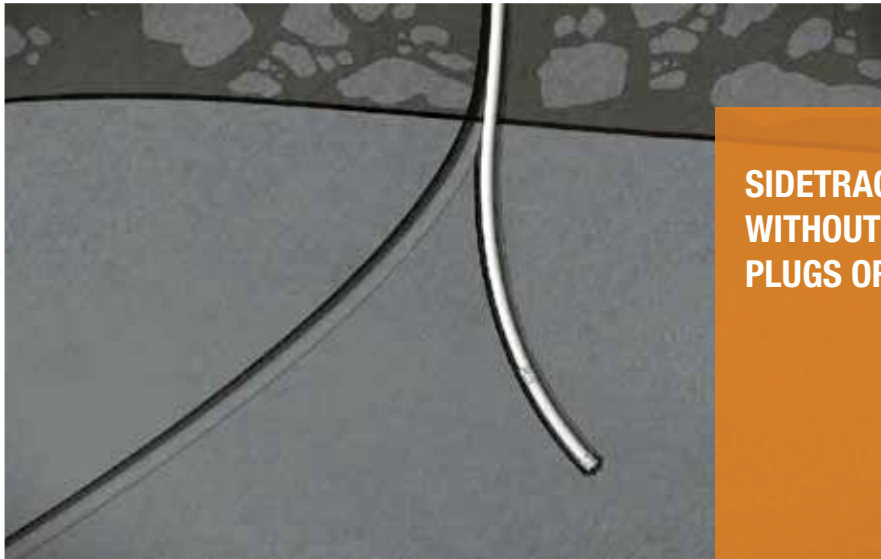
Drill string	Dogleg	Deg. per m.	Radius [m]
N	8	0.27	215
N variable wall	12	0.4	145
H	4	0.13	430
H variable wall	8	0.4	215

During drilling the achieved dogleg will vary depending on the geological formation, the DeviDrill setting, equipment wear and drilling parameters.

The orientation is held near the bottom of the hole and thereby controlled very accurately, resulting in an extremely smooth curve with a stable curvature aiming the borehole towards the specified target.

DOGLEG IS CALCULATED FROM THE CHANGE IN AZIMUTH AND INCLINATION

St Depth (m)	Direction (Az)	Inclinaison	Northing	Easting (m)	Elevation	Turn Rate	Build Rate	Dogleg
442.00	185.21	-78.70	0.00	0.00	0.00	0.00	0.00	-
443.00	185.44	-78.79	-0.19	-0.02	-0.98	0.00	0.00	-
444.00	186.08	-78.91	-0.39	-0.04	-1.96	0.00	0.00	-
445.00	186.74	-79.10	-0.58	-0.06	-2.94	15.30	4.00	4.97
446.00	187.51	-79.34	-0.76	-0.08	-3.93	20.70	5.50	6.76
447.00	188.77	-79.56	-0.94	-0.11	-4.91	26.90	6.50	8.22
448.00	190.03	-79.79	-1.12	-0.14	-5.89	32.90	6.90	9.16
449.00	191.49	-80.02	-1.29	-0.17	-6.88	39.80	6.80	9.85
450.00	192.77	-80.22	-1.46	-0.21	-7.86	40.00	6.60	9.63
451.00	193.83	-80.45	-1.62	-0.24	-8.85	38.00	6.60	9.28
452.00	195.06	-80.69	-1.78	-0.29	-9.83	35.70	6.70	8.98
453.00	195.80	-80.95	-1.94	-0.33	-10.82	30.30	7.30	8.82
454.00	196.41	-81.21	-2.08	-0.37	-11.81	25.80	7.60	8.64
455.00	197.01	-81.48	-2.23	-0.41	-12.80	19.50	7.90	8.46
456.00	197.67	-81.68	-2.37	-0.46	-13.79	18.70	7.30	7.83
457.00	198.23	-81.94	-2.50	-0.50	-14.78	18.20	7.30	7.77
458.00	199.03	-82.26	-2.63	-0.55	-15.77	20.20	7.80	8.31
459.00	199.91	-82.51	-2.76	-0.59	-16.76	22.40	8.30	8.85
460.00	200.70	-82.75	-2.88	-0.63	-17.75	24.70	8.10	8.74
461.00	201.88	-82.97	-3.00	-0.68	-18.74	28.50	7.10	7.99
462.00	203.01	-83.27	-3.11	-0.72	-19.74	31.00	7.60	8.51



SIDETRACKING WITHOUT CEMENT PLUGS OR WEDGES

SIDETRACKING

When the first target is reached, the borehole can be sidetracked and aimed towards a new target by cutting the previous curve.

“Cut the curve” means that the sidetracked borehole is cut straight out of an existing curve. The curve must be a DeviDrill section of the hole where the curvature has a dogleg of at least 8.

The cut is performed with a regular core barrel, and is usually completed in 3-4 hours.

Wedging and cement plugs are methods used when the curvature is not sharp enough to cut. These methods are more time consuming and may take 1-2 shifts to complete.



SURVEY INSTRUMENTS

Borehole surveys are an important part of DCD and are performed at frequent intervals to ensure the planned path and dogleg are achieved. Therefore a magnetic survey instrument and an orientation instrument are always included in the start package. If magnetic disturbance is expected, e.g. drilling in iron ore, a non-magnetic instrument can also be included.

The instruments are (see product brochure for further details):



DeviDip orientation instrument	
Inclination accuracy	± 0.1°
Azimuth accuracy	Not measured
Orientation (tool face) accuracy	± 0.2°



PeeWee magnetic instrument	
Inclination accuracy	± 0.1°
Azimuth accuracy	± 0.5°
Orientation (tool face) accuracy	± 0.2°



DeviFlex non-magnetic instrument (optional)	
Inclination accuracy	± 0.1°
Azimuth accuracy	± 0.01° per station
Orientation (tool face) accuracy	± 0.2°

ACCURACY

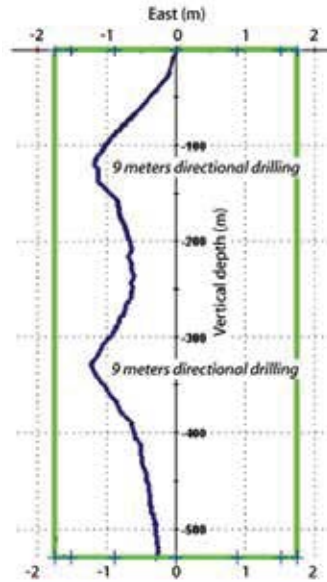
With DCD, it is possible to significantly increase the accuracy of a borehole. Boreholes are always influenced by a natural deviation that, if not compensated for, will move the borehole away from its intended target. The DeviDrill can steer a borehole in any given direction and bring it back to the planned path.

Most holes will hit their intended target with one DCD correction, but extremely deep holes or in areas with high natural deviation, a second correction may be required as the hole progresses.

The accuracy limits are specified by the project geologists, and may vary from project to project. The most common limits in the Devico projects are:

Depth	Limit (radius)
500 to 1000	5-15 m
1000 m and deeper	10-25 m

Narrower limits can normally be achieved, though these may take further time to complete.



High accuracy hole with 1.5 m limit over 500 m (borehole in blue)

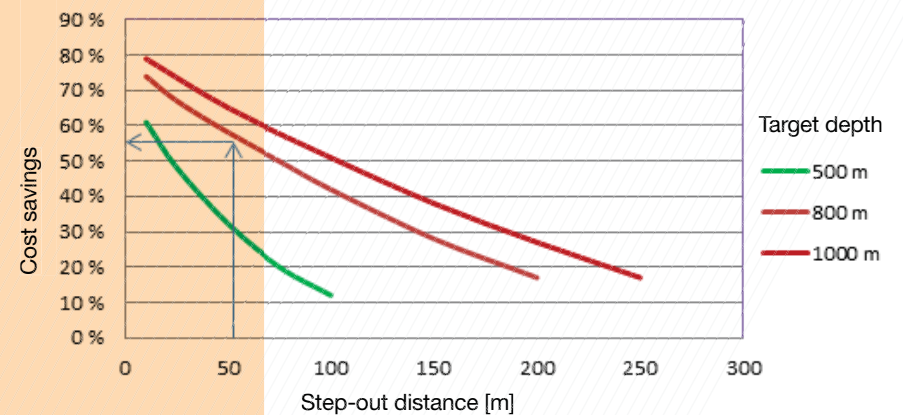


COST SAVINGS

In mining exploration projects there is a potential for significant savings by utilizing the DCD technology. Sidetracking and DCD reduces the total length of a drilling program, while the production rate is kept high.

The saving potential is strongly related to the depth of the exploration area and the density of the drill targets. Deeper ore bodies with short distance between targets (step-out distance) are likely to generate higher cost savings than shallow targets.

POTENTIAL COST SAVINGS AS FUNCTION OF DISTANCE BETWEEN TARGETS AND TARGET DEPTH



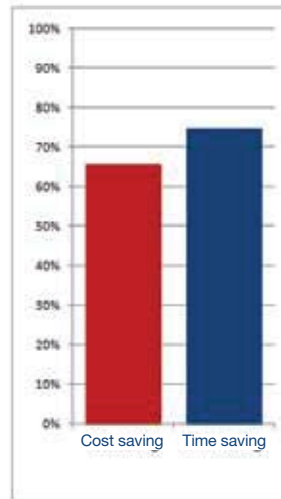
COST SAVINGS

Devico has prepared a calculator, available at www.devico.com, where the users can quickly estimate the potential cost and time savings of utilizing the DCD technology in their own drilling program.

For a more accurate analysis the Devico planning service may be utilized free of charge. More information about this on page 4.

ESTIMATED COST SAVING DIRECTIONAL CORE DRILLING (DCD) COMPARED TO RE-DRILLING FROM SURFACE

Activity description	Qty/prices	
One or two shift operation	1	
Time to move rig to new site	1 shift	
Cost to move rig to new site	1500 €/shift	
Target vertical depth	900 m	
Step-out distance	25 m	
Production rate directional drilling	10 m / shift	
Rig & crew shift rates during directional drilling	1000 €/shift	
Production rate standard drilling	20 m/shift	
Cost per meter standard drilling	€ 90	
Cost per meter casing	€ 100	
Required casing trough overburden	10 m	
Re-drilling from surface	€ 73 600	41 shift
Directional drilling	€ 11 850	3 shift
Target drilling	€ 18 354	7 shifts
Approx. saving	€ 48 396	31 shifts
Percent saving	66%	75%
Proposed kick-off depth (KOP)	624 m	
Move proposed kick-off depth (KOP)	m	



BENEFITS

Using DCD in your exploration project has many benefits. A few of them are listed here.

COMPARED TO STANDARD WIRELINE DRILLING (RE-DRILLING FROM SURFACE)

- Reduced drilling length
- Less wear on drilling equipment
- Fewer drill sites
- Less environmental impact
- Full control over natural deviation
- Improved borehole accuracy

COMPARED TO OTHER DIRECTIONAL DRILLING TECHNIQUES

- Continuous core sample from directional sections
- Low water consumption
- All necessary equipment in small start package
- Fits directly on NQ™* drill string
- High penetration rate in hard rocks
- Easily adjustable dogleg
- Higher dogleg due to smoother curvature
- Drill string rotation also during steering
- Directional surveys performed at hole bottom (through DeviDrill bit)
- Full N-size borehole and no additional reaming required

*Q™ is a trademark of Boart Longyear

BENEFITS

The table below compares the DeviDrill with standard mud motors. The DeviDrill recovers a core, requires significantly less water, has a more accurate orientation control, and shows a comparable penetration rate in sedimentary rocks, while being superior in hard rocks.



DEVIDRILL VS MUD MOTORS

Parameter	Mud Motors	DeviDrill
Water flow	200 - 400 l/min	40 l/min
Water pressure	30 bar	30 bar
RPM	100 - 300	700 - 900
WOB	25 kN	45 kN
Rock sample	None (cuttings)	Core
Penetration rate soft rock	6 - 8 cm/min	10 - 14 cm/min
Penetration rate hard rock	1 - 2 cm/min	6 - 10 cm/min
Dogleg setting	Fixed	Adjustable
Drill string	B-size	N
Hole size	N (reaming required)	N-size (no reaming required)
Borehole survey	Behind motor	Ahead of bit
Orientation control	At surface	At hole bottom
Water pump	High capacity	Standard
Drill bit	Navy bit	Impregnated or surface set

REQUIREMENTS

For optimal implementation of DCD in your drilling project, a few requirements are set:

N-size drill string (ID 60.3 mm and OD 69.9 mm)	Required
Rotation control	300 - 1200 RPM
Feed control feed/pull	Min. 5000 kg
Drill pipe clamp	Required
Wire line winch pull force	1000 kg
Mud pump flow rate/pressure	60 l/min and 70 bar
Discharge pulsation damper/compensator	Required
Relief/by-pass valve	Required
Suction filter	Required
Flow meter	Preferred 0-100 l/min (+/- 2 l/min)
Pressure gage	Required (+/- 1 bar)
Boart Longyear spearhead	Required
Mud mixer and cleaning system	Preferred
Drill bits	76 mm, Devico specification
Reaming shells	76 mm
Reaming shells over size 77 mm	In case of extreme geo-technical conditions

THE FOLLOWING SHOULD ALSO BE PROVIDED:

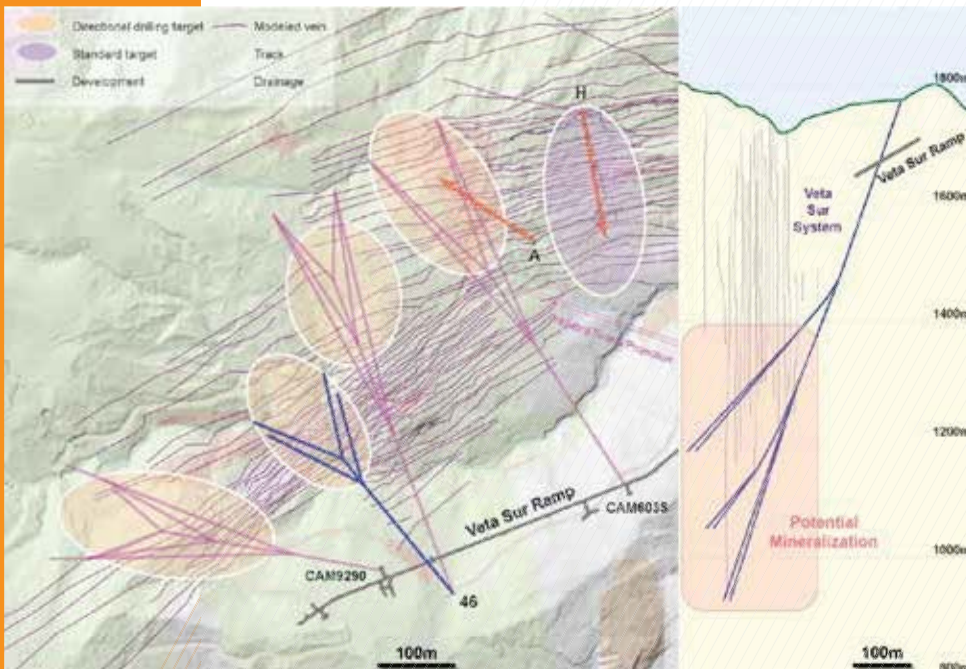
1. Working conditions in order to service the equipment, including container and internet access
2. Support obtaining work permits or VISA(s), if necessary
3. Board and lodging
4. Security protection for Devico personnel and equipment
5. Surface transportation vehicles.
6. Saving Devico from any delays, breakdowns or non-compliance of terms by others (third parties involved)

CASE STUDIES

CONTINENTAL GOLD

During most of 2014 Devico has been working at Continental Golds property in Colombia providing directional core drilling services. The drilling program has proven highly successful, and Continental Gold highlights the following advantages:

- Substantial time and cost savings due to reduced drill meterages and better drilling productivity relative to the number of conventionally-drilled deep holes required to effect similar coverage; and
- The ability to better target key areas, control drill deviations and achieve better angles of attack on mineralized zones.



Drilling program for Platform 46

CASE STUDIES

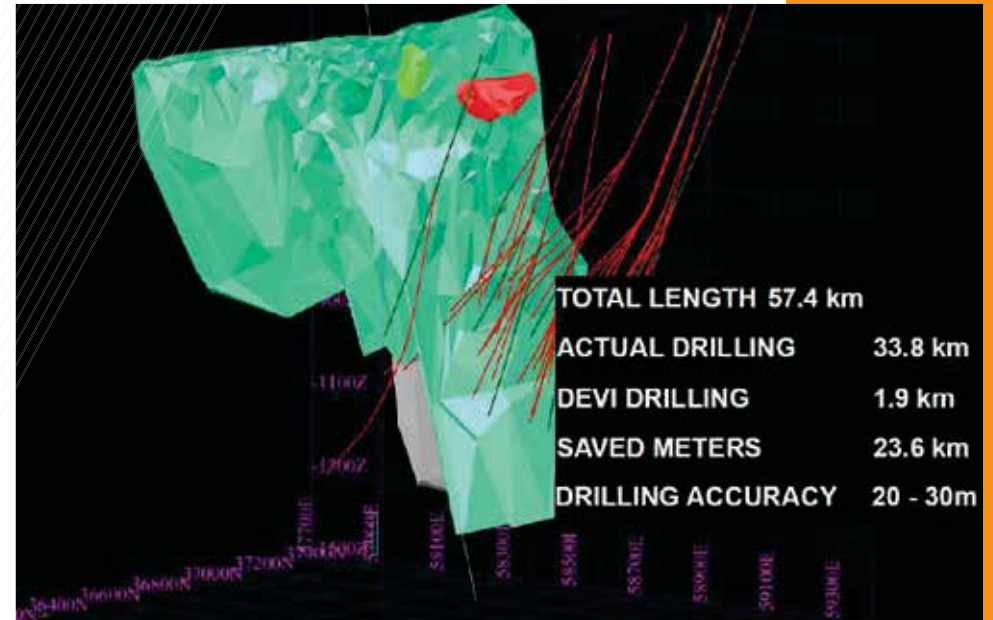
AGNICO-EAGLE

Since 2009 Devico has worked for Agnico-Eagle in their deep drilling program at the Kittilä mine in Finland. As the holes often go down to 1,200 meters, a significant amount of time and meters is save by branching off holes.

During the first year of drilling more than 23,000 meters were reported saved in a 57,000 meter drilling program, leading to time savings of 30 % and cost savings closer to 25 %.

“From January to September 2009, we drilled 45 holes (26,750 meters) using Devico technology. In a conventional drilling approach we would have drilled 47,000 meters, so Devico saved 20,750 meters.”

Jukka Välimaa – Senior Geologist



Summary of the DCD project after the first year of operation



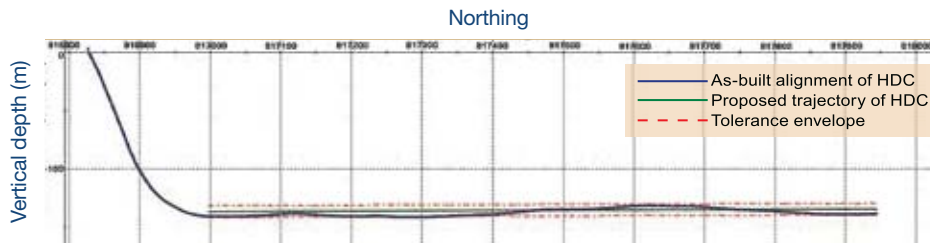
CASE STUDIES

HATS STAGE 2A

DCD is also commonly used in the geotechnical and tunneling industry. The ability to steer a borehole and extract core samples along a planned tunnel path can significantly reduce the risks during the construction work.

In the HATS 2a tunneling project in Hong Kong, DCD was used to investigate over 5000 m section through a complex and uncertain geological formation.

Boreholes up to 1250 m were drilled horizontally within a 5 m radius of a predefined path. The information gathered was later made available to the tenderers, helping to improve the cost estimation of the construction works.



Coring along a planned path to investigate planned tunnel trajectory



CASE STUDIES

LUNDIN MINING

Due to the great depths and unpredictable natural deviation in the area, AGC mines in Portugal had problems delineating their reserves in a systematic pattern. Failures to hit the targets and missing the ore zones lead to higher exploration expenses than necessary.

“Having the Devico crew on site helps us to hit our planned targets at depths down to 1,300 meters in an environment where drill hole deviation is difficult to predict. We would not be able to target accurately without it.”

**Bob Carmichael – Group Manager,
Resource Exploration**

GUYANA GOLD

Much for the same reason as Lundin Mining, Guyana Gold used the Devico technology to both increase the target accuracy and reduce exploration costs. The thin ore body stretches down more than 2,000 meters, and accurate drilling is critical to plan the development of the mine.

“Cost-savings per hole (instead of drilling holes from surface): 45-50% (estimated).”

Rex Camit – Project Geologist



Rorys Knoll, Guyana

