

# Directional Core Drilling

## Advantages of exploring the path of a planned tunnel alignment



**STYR**  
Directional Core Drilling



# Devico AS

- Established in 1988
- Trondheim, Norway
- **Deviation Control = Devico**
- Directional core drilling (DCD)
- Survey instrumentation
- Mining & Civil





# Core drilling in tunneling

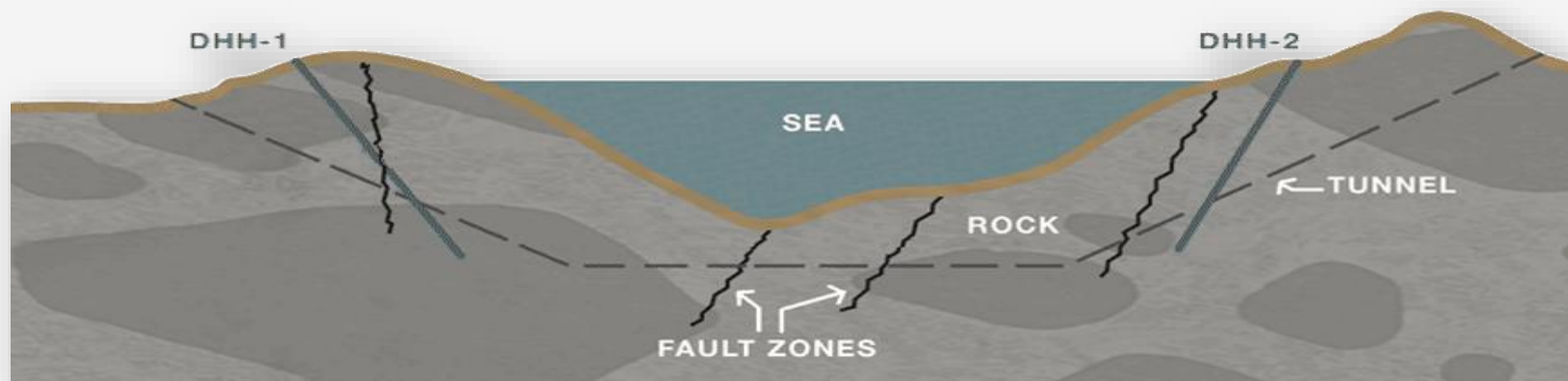
- Retrieve samples from the rock formation
  - Test mechanical properties
  - Detect changes in geology
- Determine sediment depth
- Investigate weak zones indicated from other techniques (geophysics, surface mapping, etc.)





# Limitations with traditional core drilling

- Intersection area limited
  - «Spot» mapping of the formation
- Intersection angle limited
- Multiple holes require multiple drill sites





# Directional core drilling (DCD) Technology

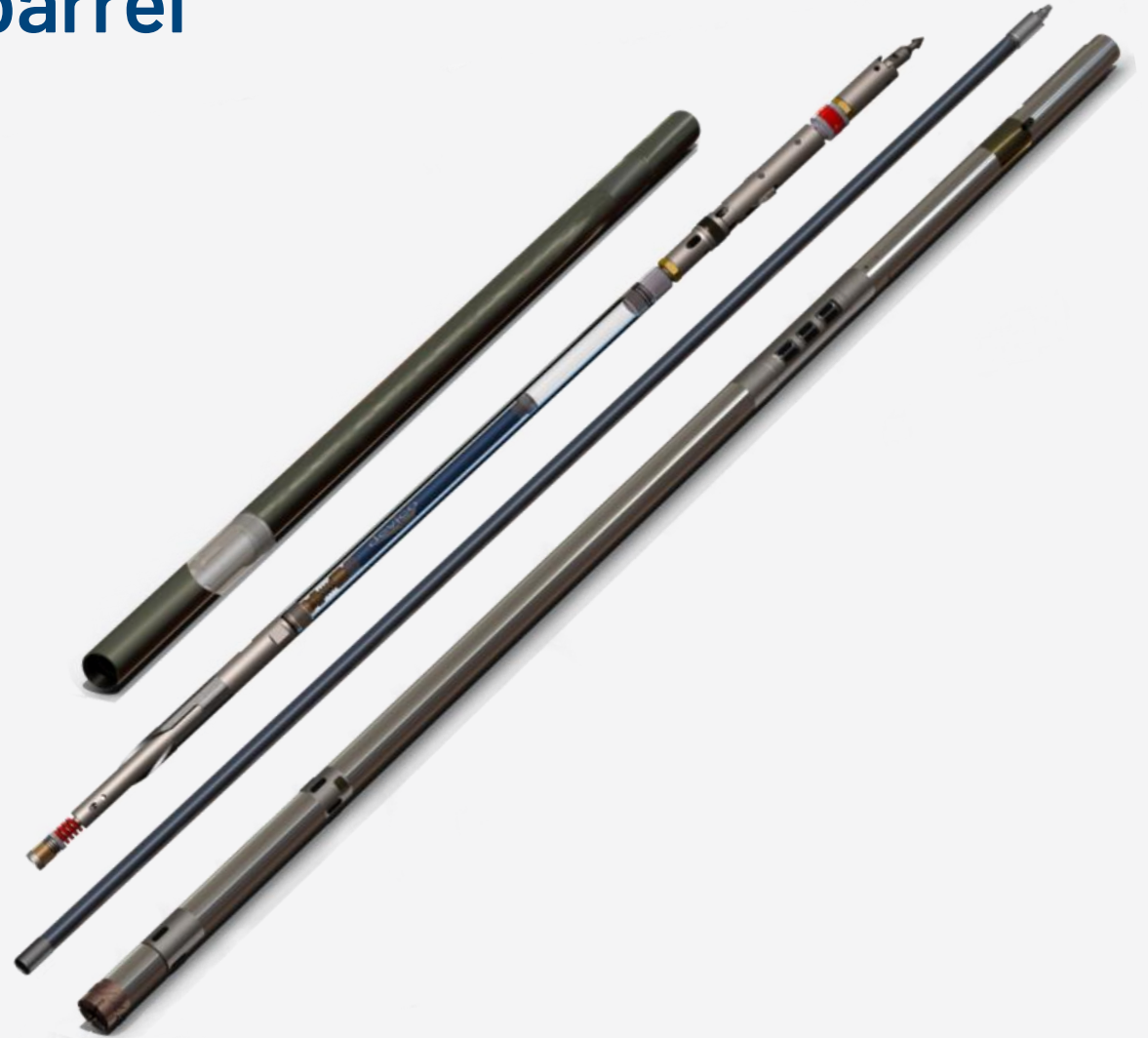
- Supplied by Devico AS
- Special core barrel for steering hole
  - Compatible with traditional drilling technology
  - Exploration drilling in mining sector
  - Geotechnical investigations
- Replaces traditional core barrel when steering is required
- Curves the hole in a pre-set direction





## DeviDrill™ Directional core barrel

- Mainbody
- Rearbody
- Pumping Assembly
- Navigation Instrument
- Innertube (Wireline operated)
- Total weight: 75 Kg
- Length: 4500 mm
- Core Length: 3 m

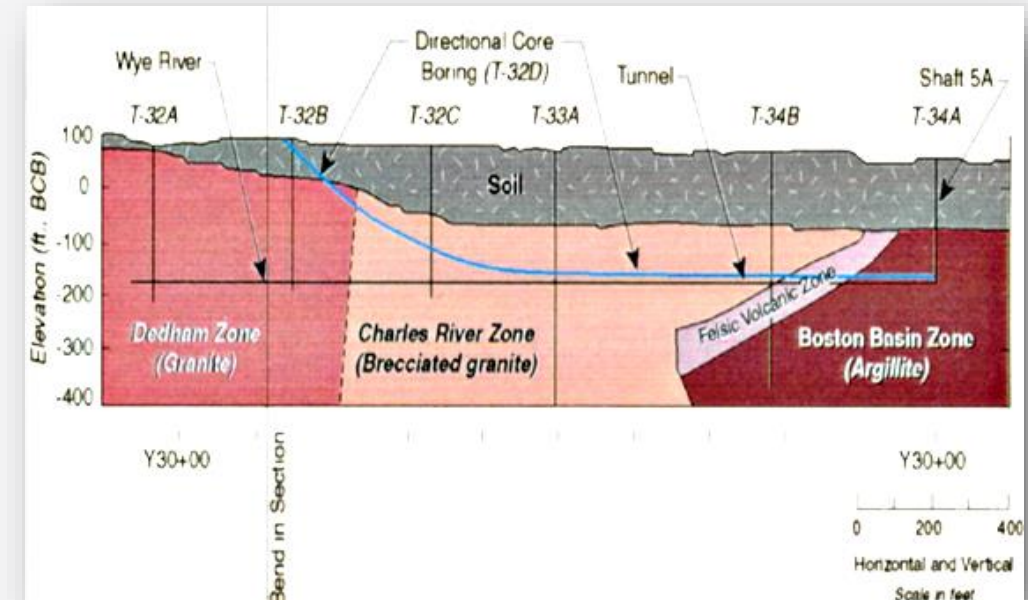






# DCD in tunneling

- Used in combination with traditional coring
- Adjust hole path as desired, to:
  - Turn hole parallel with planned alignment
  - Follow along planned alignment
- Less dependent on drill site location





## Information gained

- Continuous core sample along tunnel alignment
  - Same width of fault zones and other geological formations as construction phase
  - Same direction of intersection of faults and fractures
  - Same location of intersection
- Borehole for water and geophysical testing

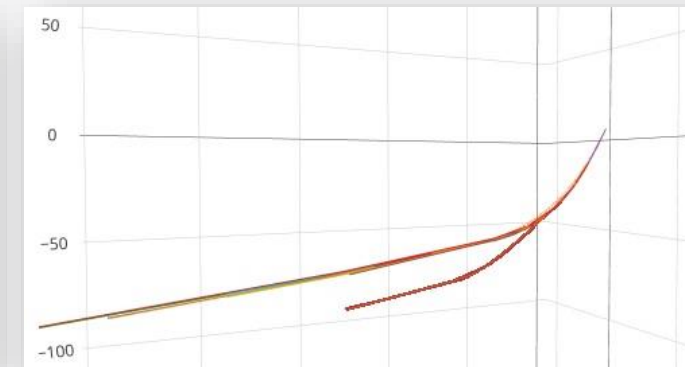






## When to use DCD

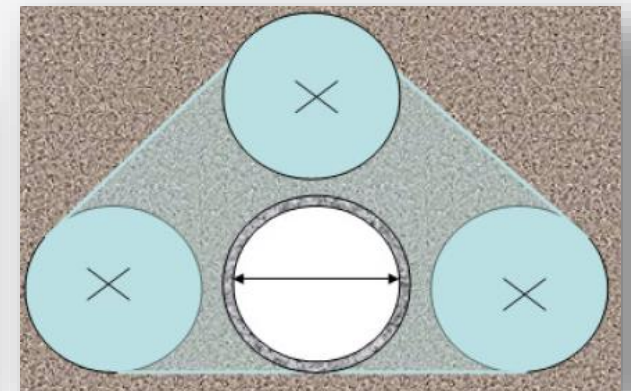
- Can be used in any tunneling project, but particularly useful in:
  - Complex geology
  - Under urban areas / water
  - Restricted access
- Investigate rock formation at various depths (sidetracking)





# Technical considerations – Borehole path

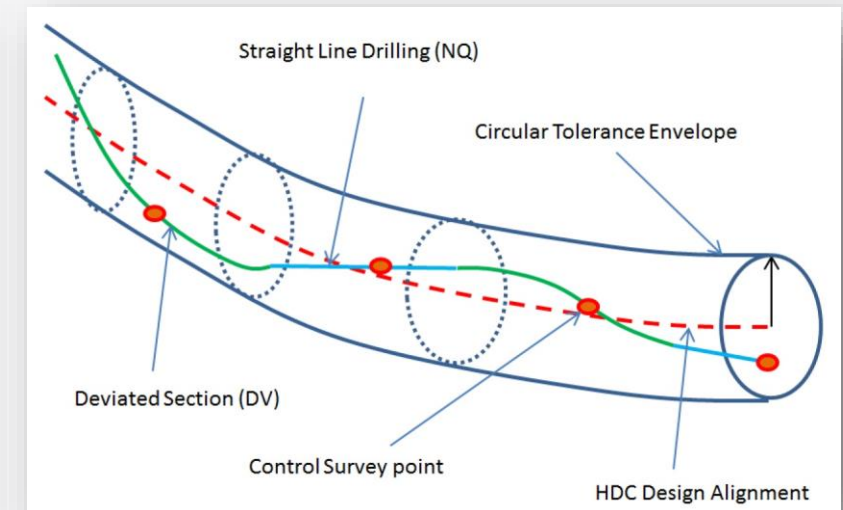
- Rock formation required
  - No steering in sand or sediments
- Generally, avoid drilling in planned tunnel profile
  - Leakage
  - Drilling equipment left in hole
- Positioning hole just above crown typically most beneficial
  - Where most stabilization occurs
  - Formation generally improves with depth





# Technical considerations – Tolerance envelope

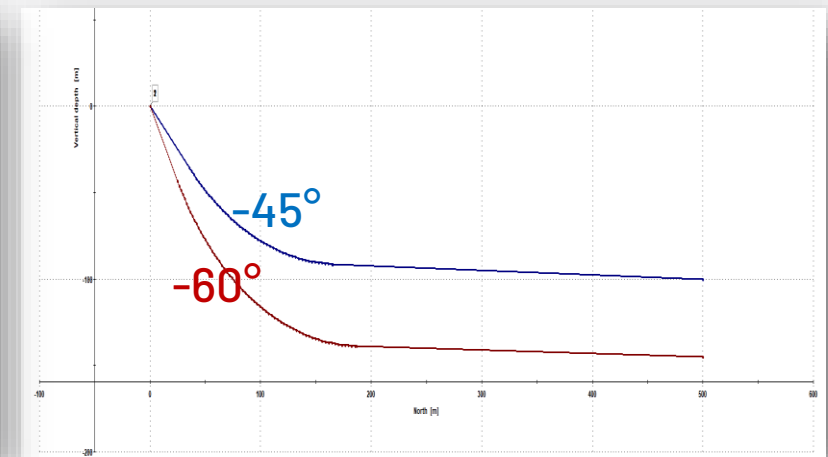
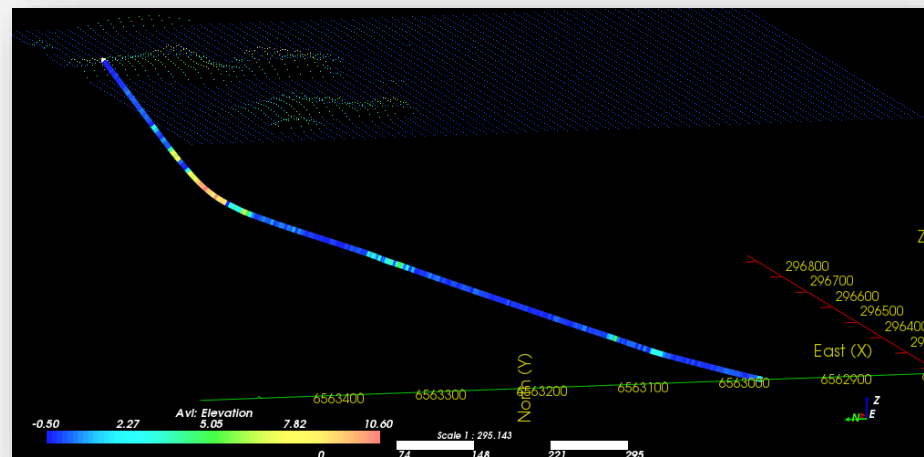
- While parallel with alignment the hole will deviate
  - Initiate directional drilling to correct back on track
- Define maximum allowable deviation based on target of investigation, e.g. 5 m radius





# Technical considerations – Curve and start angle

- Directional drilling is gradual
  - About 200 m radius, or  $8^\circ$  per 30 m steered
- Drill hole start angle must be set accordingly to reach the target alignment
  - Too perpendicular and hole will not align in time
  - $-30^\circ$ – $-45^\circ$  are typical adjustments

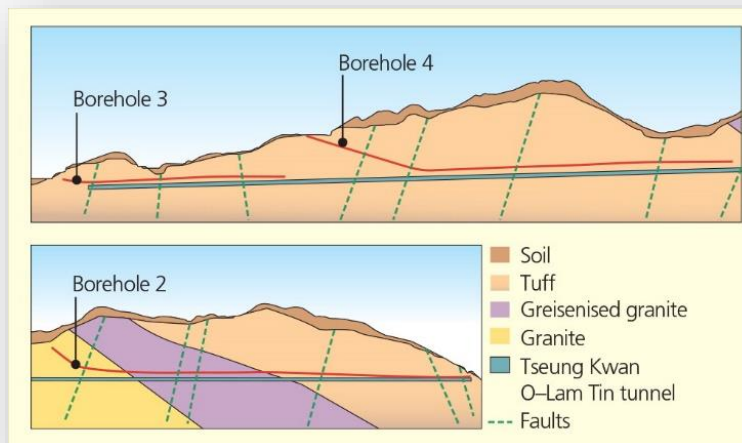






## Limitations with DCD – Hole and core diameter

- Directional drilling performed in N-size, i.e. 76 mm hole diameter
  - Some geophysical tools designed for H-size only (96 mm)
- Core diameter
  - Straight sections: 48-52 mm
  - Curved sections: 31.5 mm
- Preferable to finish DCD before reaching expected fault zones





# Example Projects

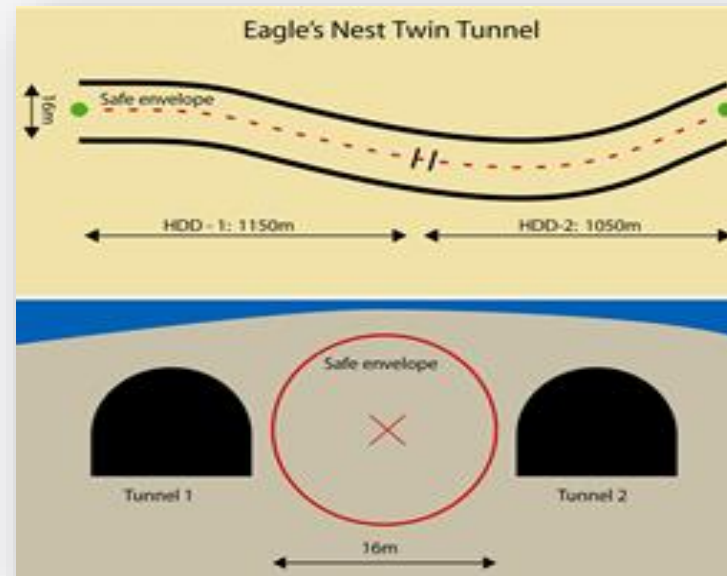






## Eagle's Nest – Hong Kong

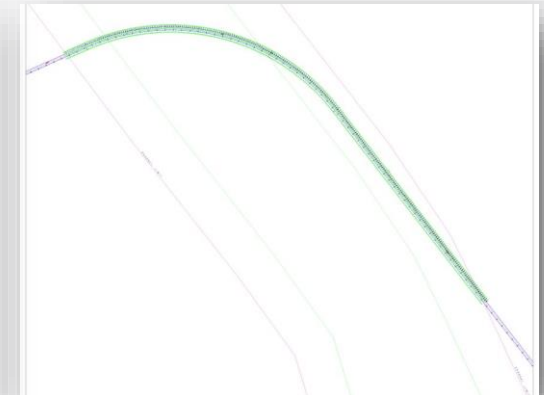
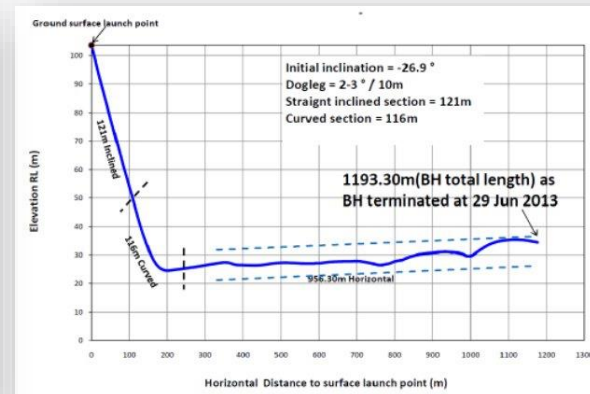
- Two boreholes drilled from northern and southern tunnel portals
- Borehole lengths: 1150m & 1050m
- Natural Deviation
- Information gained





## Jurong Island - Singapore

- 1000+ m hole drilled along the path of planned cable tunnel
- Hole must stay within 10-meter from the planned path, with a near 90-degree change in direction before reaching the shoreline.
- Start with inclination of -25 degree, then horizontal





## Stad ship tunnel – Norway

- 1.7 km tunnel planned to provide faster and safer ship route
- Large diameter tunnel
- Coring programs in 2000 and 2015
- More information on geology and stabilization measures needed
  - Directional coring program in 2019





# Conclusion

- DCD can add significant value during tunnel pre-investigation
  - Reduce risk of surprises during construction
  - Improve estimate of ground support
  - Improve estimates of construction costs and time
- Particularly useful in hard-to-reach areas, e.g., sub-sea, infrastructure, remote and rough terrain

*"We took bids on the tunnel segment where we did the Devico core. The three bids were very tight – \$57 to \$58 million, or only 2.5% spread among the bidders. This is very unusual for a tunnel contract and may be attributed to having done the horizontal core."*

[devico.com](https://devico.com)

*John Kaplin (MWRA)*