Rock breaking under rolling TBM disc cutters in hard rock conditions

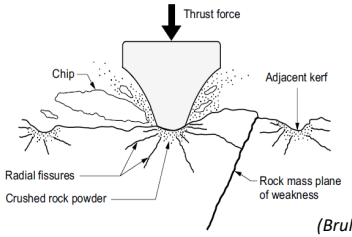
- Visualization and documentation of cracks

Solveig Vassenden

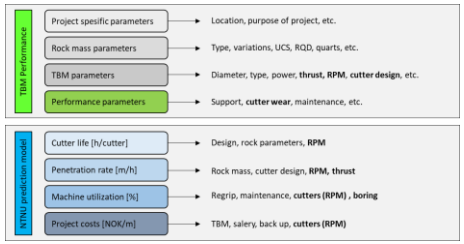
Main findings

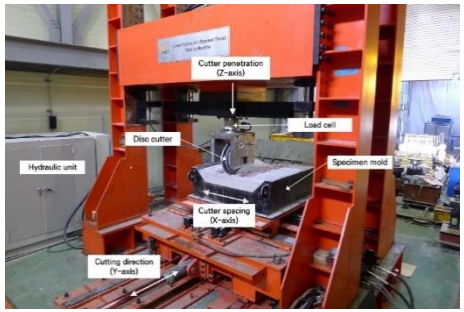
- Core samples provide valuable information about the rock breaking under disc cutters
- Cutter head speed (RPM) influences the rock breaking
- Rock breaking under the disc cutters of a full size TBM differs from the rock breaking under the disc cutter on a Linear Cutter Test (LCT)

Main goal: Increase the understanding of the rock breaking under a disc cutter of a full size TBM.



(Bruland, 1998)





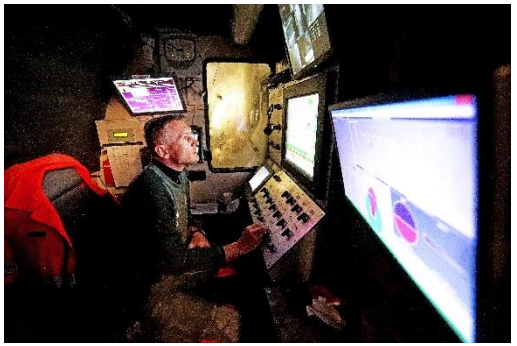
(KICT, 2015)

Objective 1: Establish an economical and time efficient method to detect and document the rock breaking under the disc cutters of a full size TBM.

Objective 2:Document the effect of different RPMs concerning rock breaking under the disc cutters of a full size TBM.

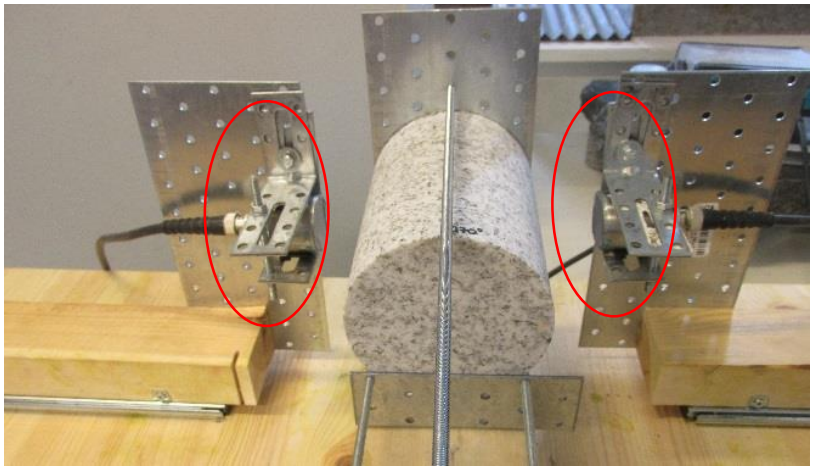
Objective 3: Detect and document the rock breaking under the disc cutter in a linear cutter test, and compare this with the results from a full size TBM.

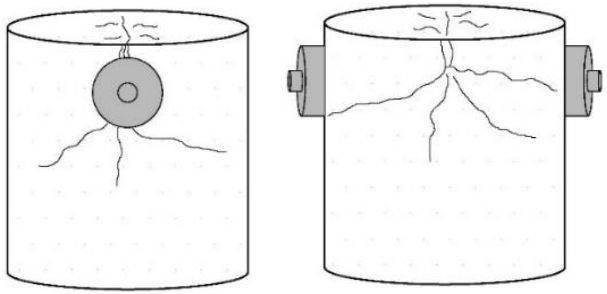
Sampling



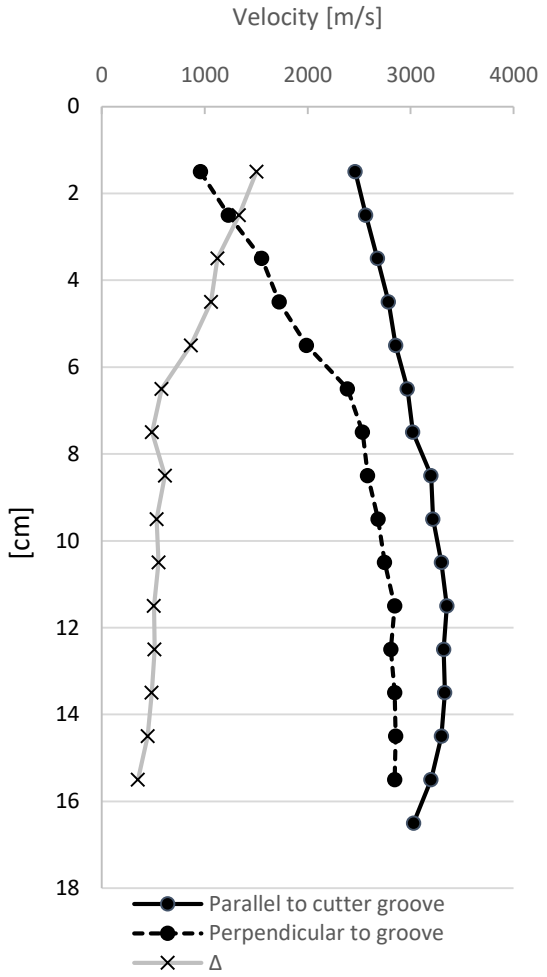
Photos: Marius Wærhaug Madsen

Detection of cracks by sound velocity measurements

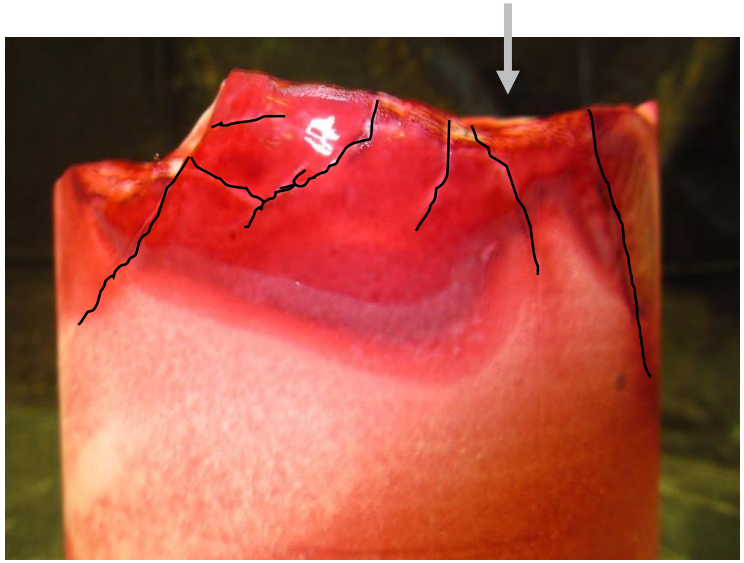


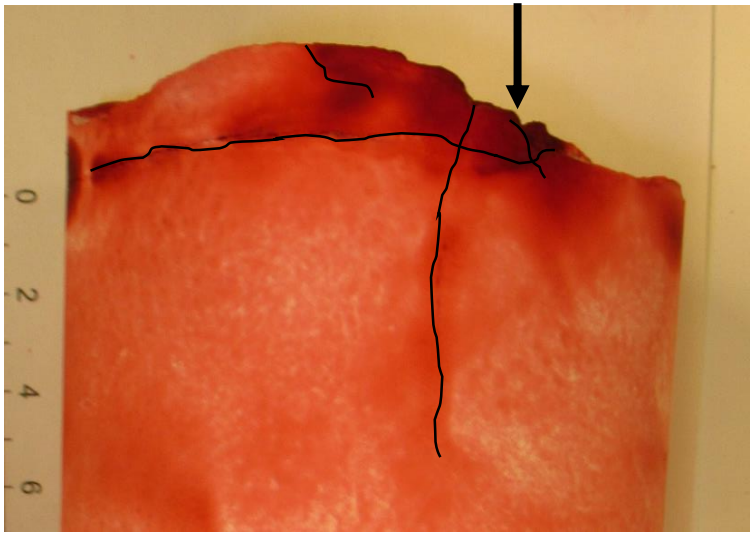


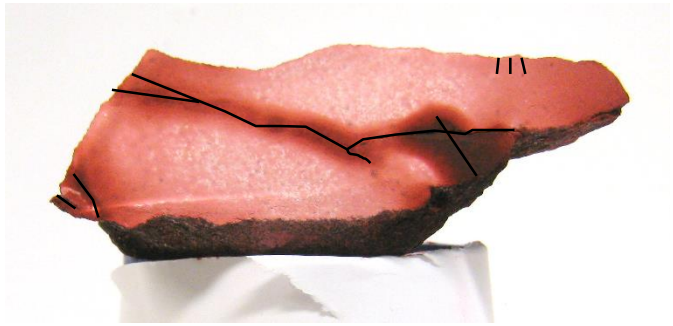
(Hannestad, 2015)



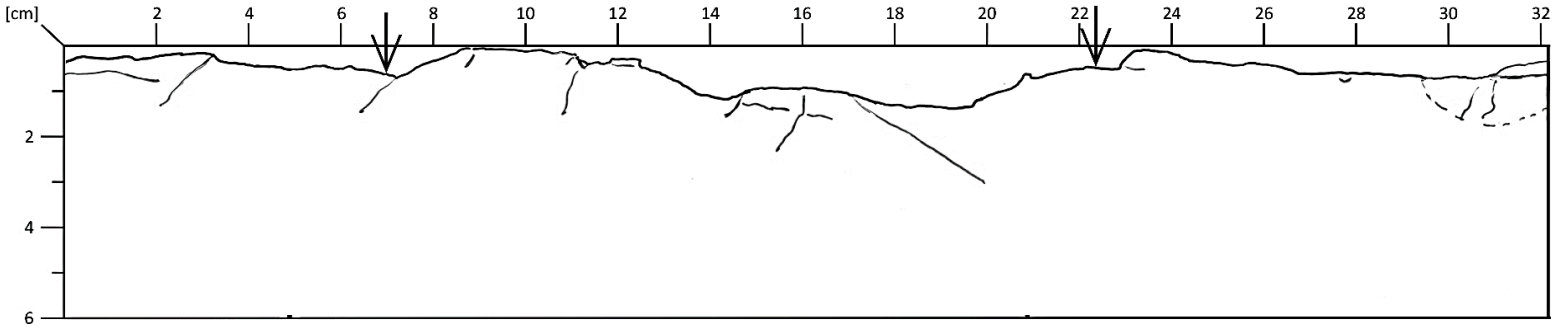
Detection of cracks by dye penetrant

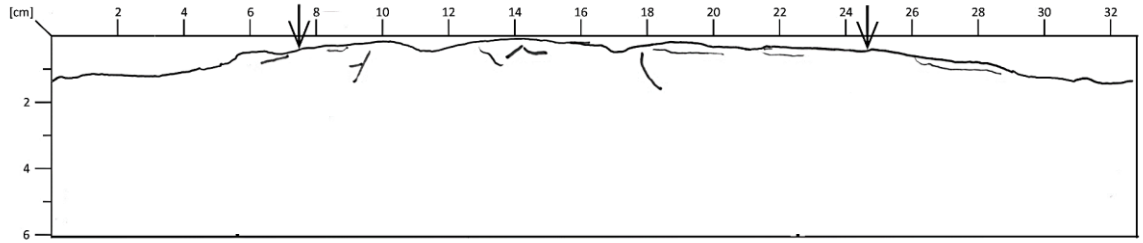


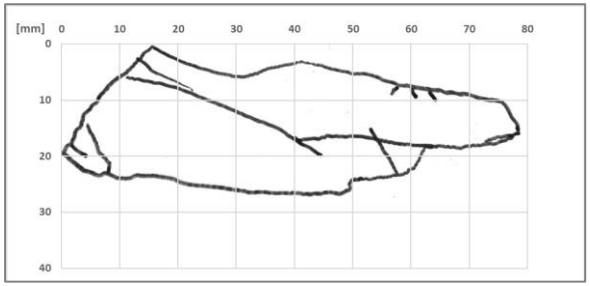




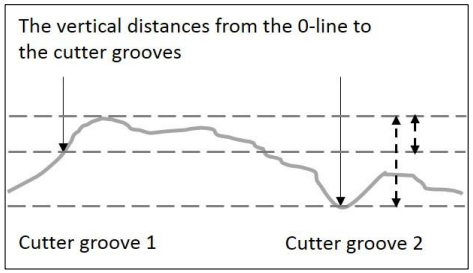
Documentation of cracks on foldouts

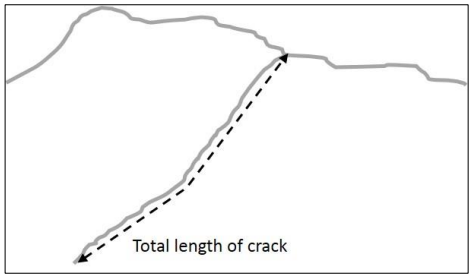


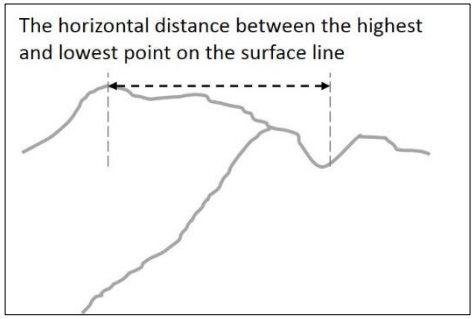




Documentation of cracks by measurements of properties

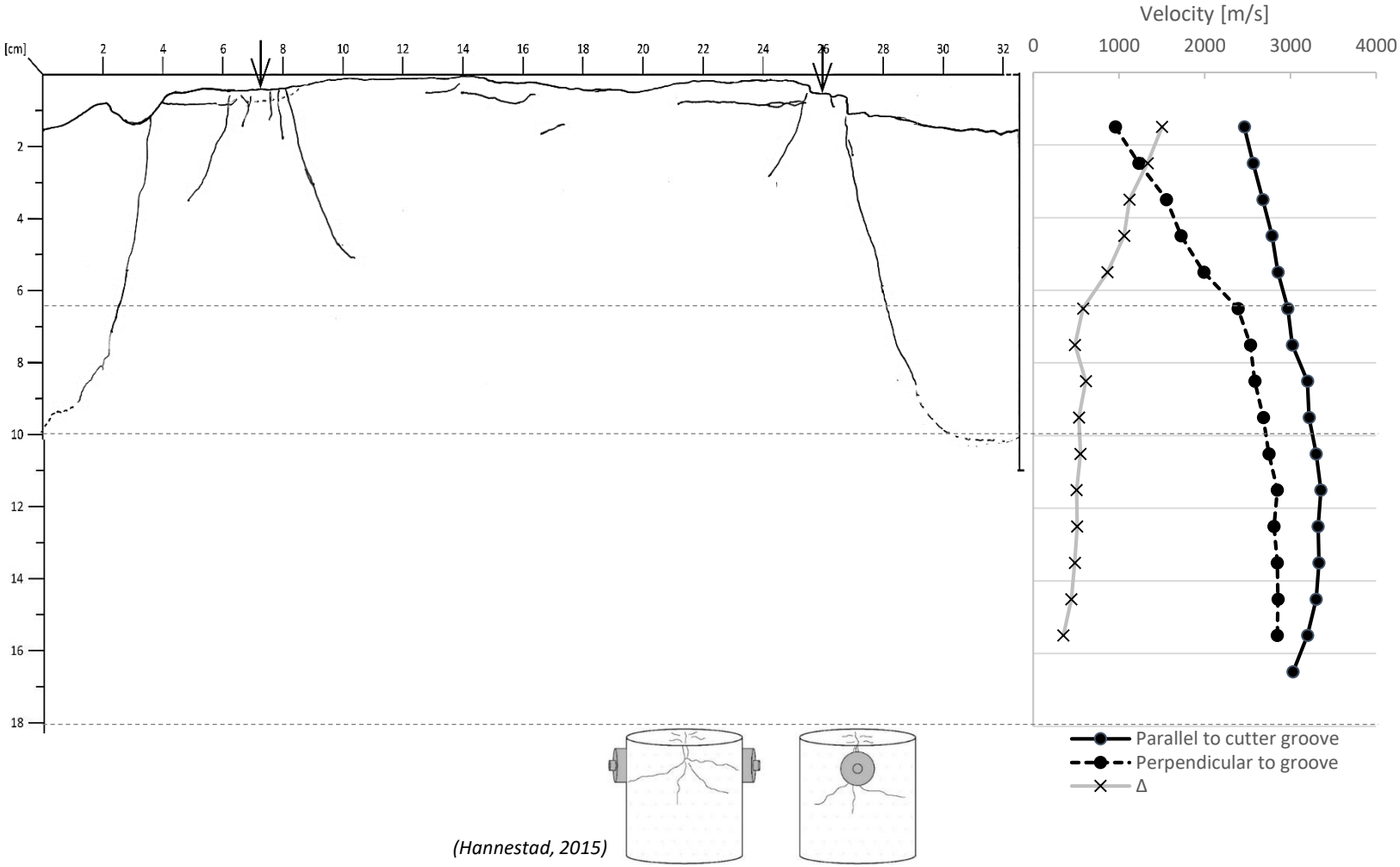






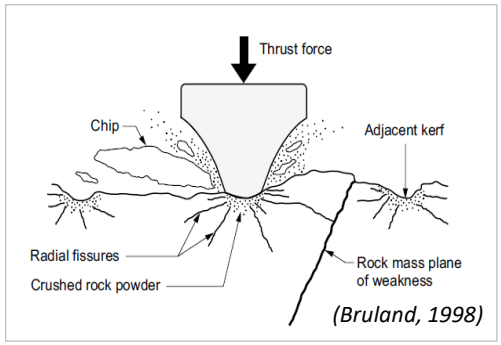
1) The horizontal distance from the basis point to the point of origin of the crack, measured counter clockwise on the core sample, and from left to right on the foldout [mm]
2) The horizontal length of the crack [mm]
3) The vertical length of a crack [mm]
4) The total length of the crack [mm]
5) The dip of the crack, measured in degrees from the horizontal line [°]
6) The dip direction of a crack, towards right or left on the fouldout [right/left]
7) The vertical distance from the 0-line to the lower end of a crack [mm]
8) The vertical distance from the point of origin to the end of a crack [mm]
9) The vertical distance from the surface line to the point of origin of the crack when this is below the surface line [mm]
10) The horizontal distance from the horizontal 0-point to the two cutter grooves, measured counter clockwise [mm]
11) The horizontal 0-point to the intersection points of the foliation, if any, measured counter clockwise [mm]
12) The circumference of the core sample[mm]
13) The length of the surface line along the circumference of the core sample [mm]
14) The horizontal distance between the highest and lowest point on the surface line [mm]
15) The vertical distance between the highest and lowest point on the surface line [mm]
16) The vertical distances from the 0-line to the cutter grooves [mm]
17) The area between the 0-line and the surface line [mm^2]

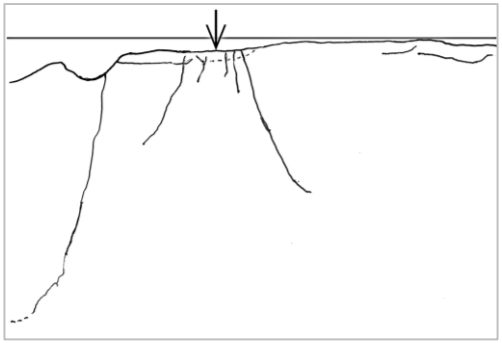
Sound velocity measurements

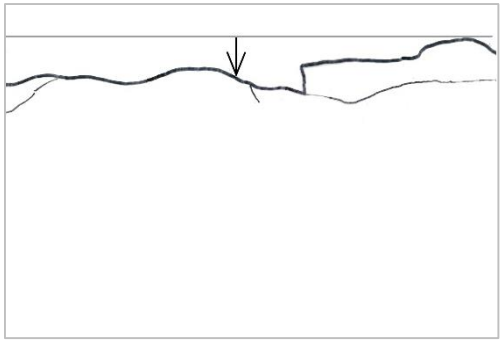


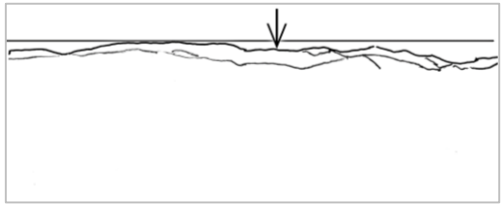
(Hannestad, 2015)

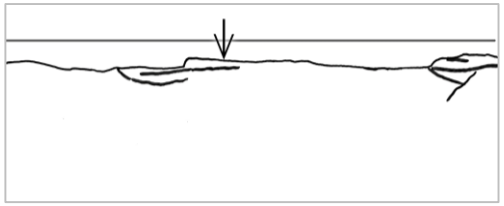
Rock breaking under disc cutters

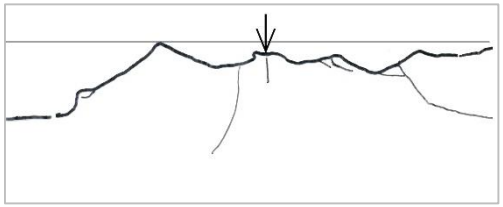


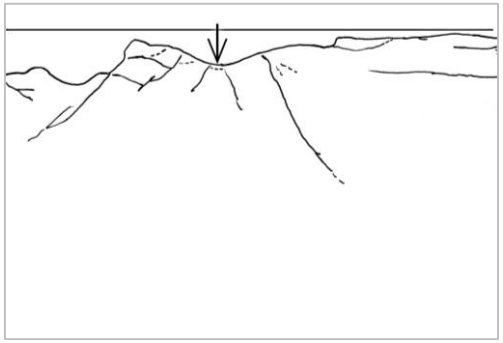


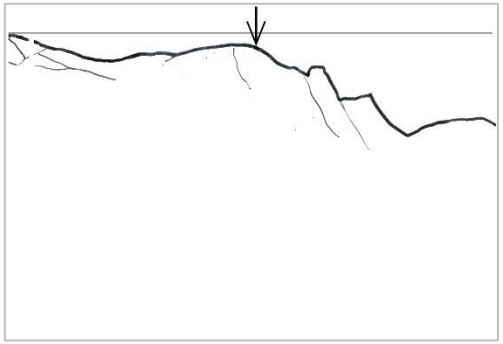


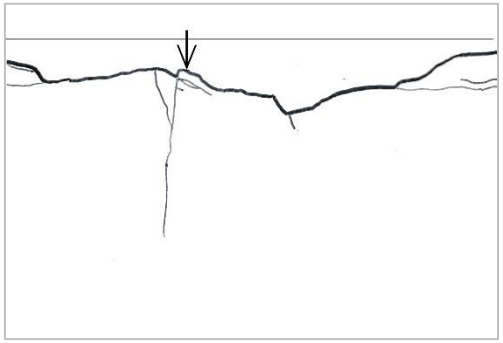




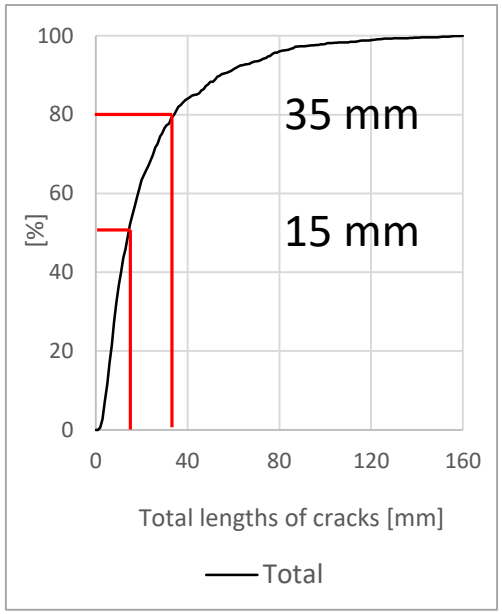


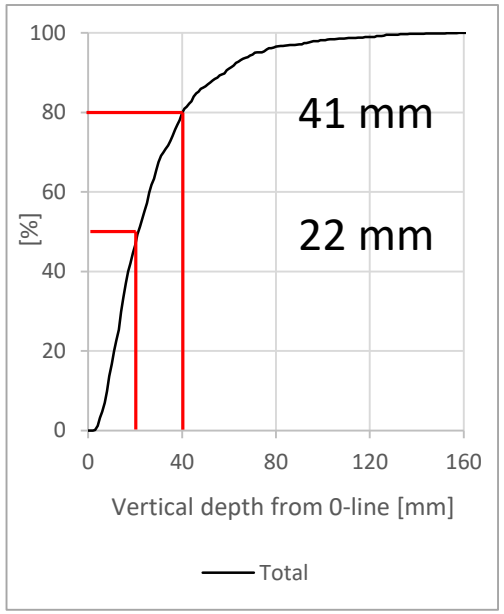


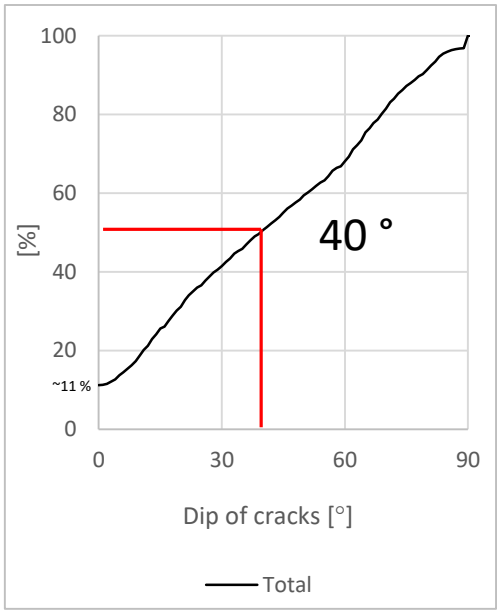


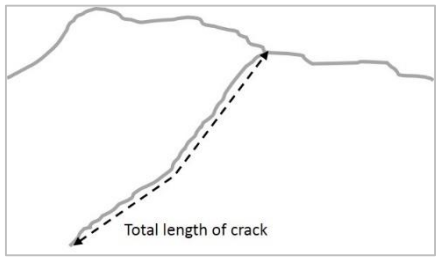


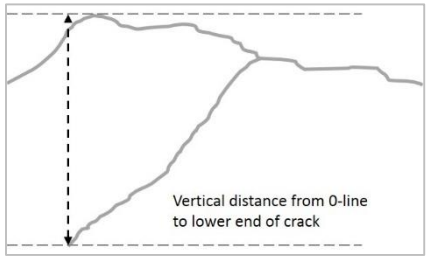
Length, depth and dip of cracks

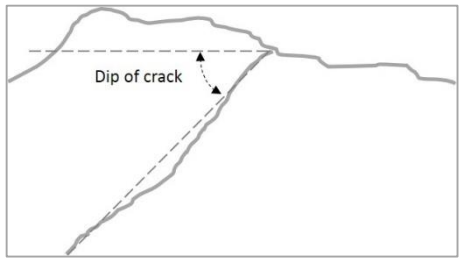




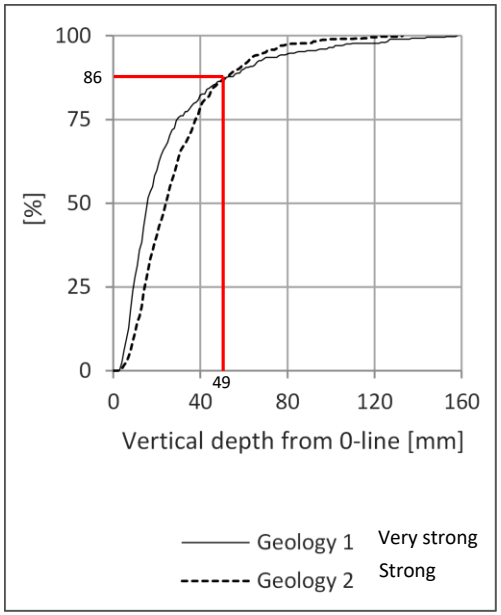


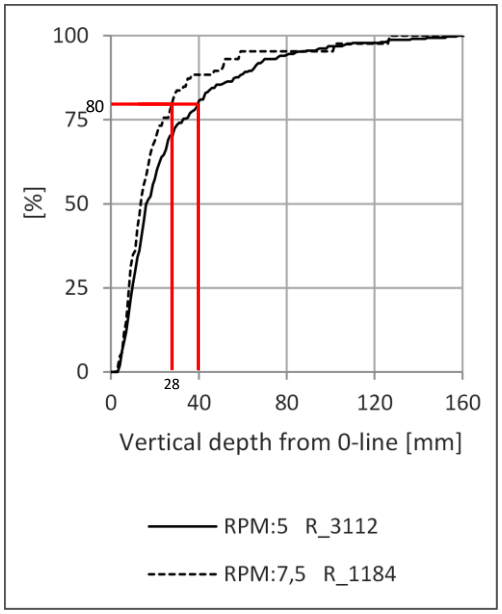




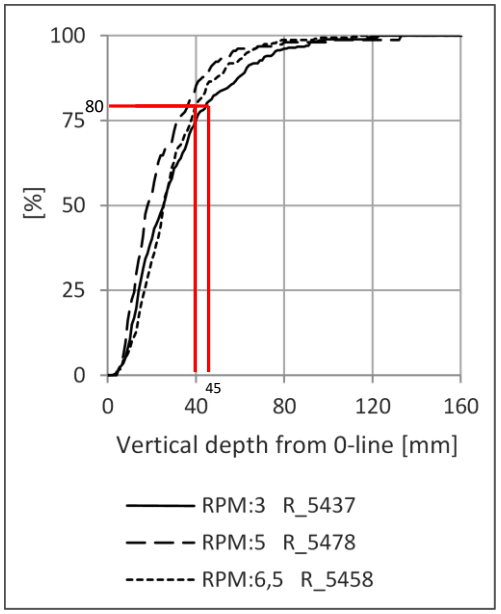


Distribution of depth of cracks

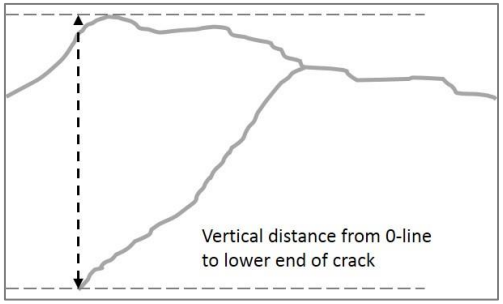




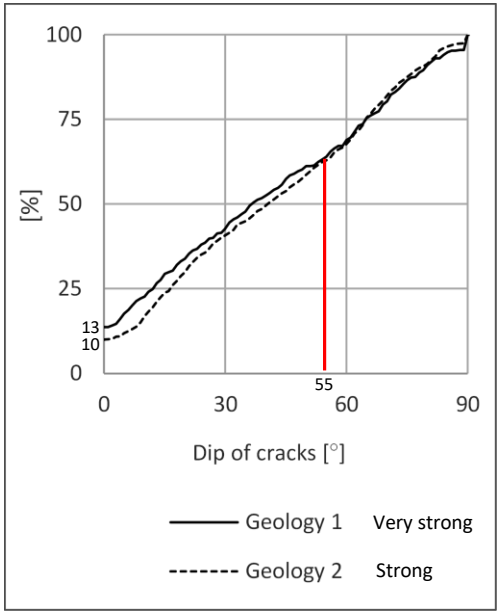
Very strong

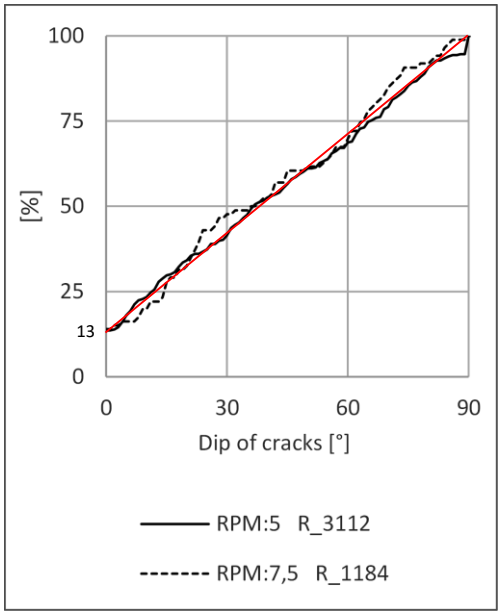


Strong

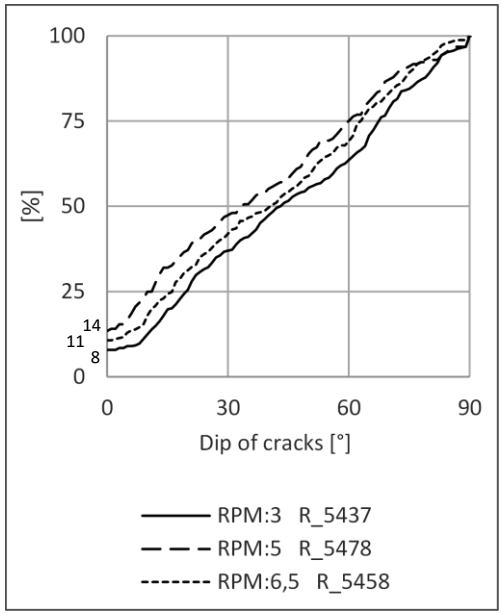


Distribution of dip angles

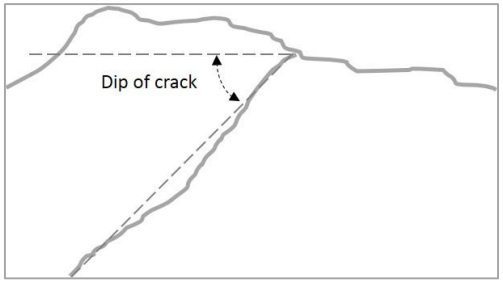




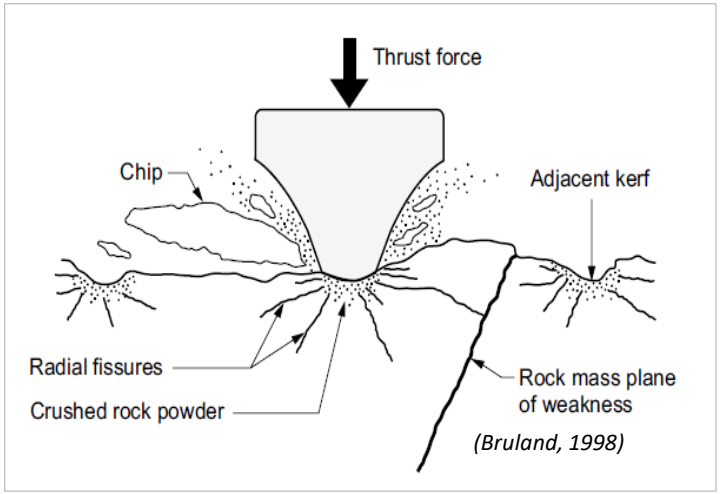
Very strong



Strong



Effect of RPM

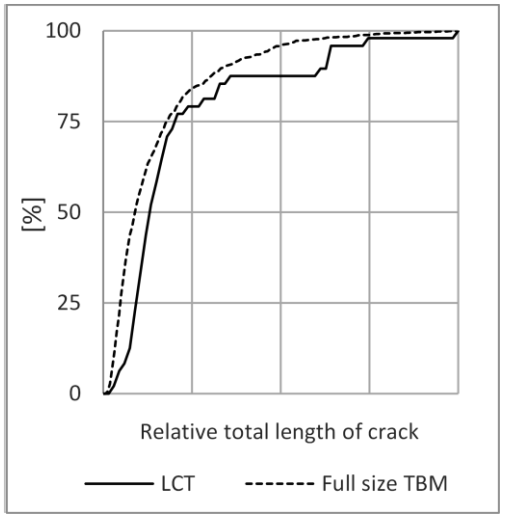


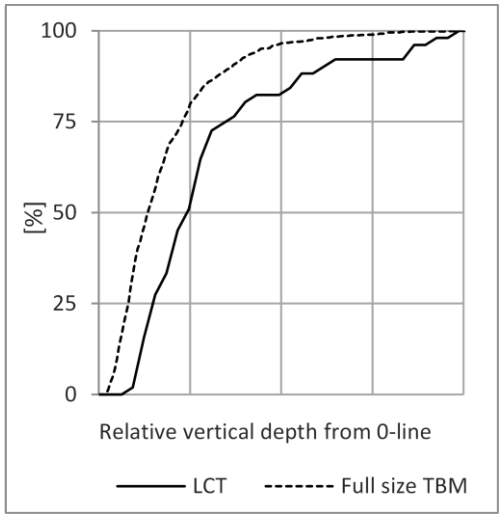
Site	UCS [MPa]	Average number of cracks
AMR Project	275-372	1,3
Nedre Røssåga, Geology 1	62-139	18,3
Nedre Røssåga, Geology 2	92-124	20,0

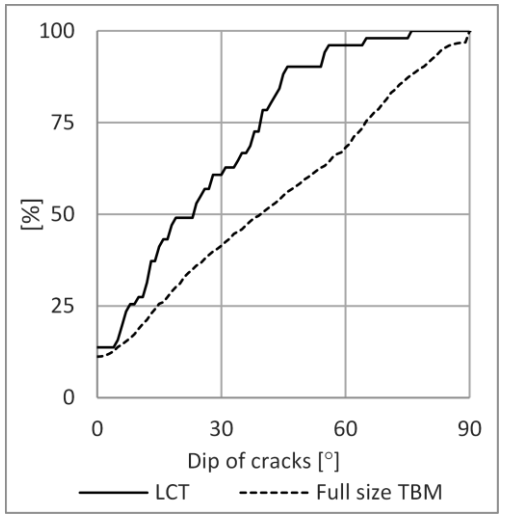
Independent of geology, the lowest RPM generated:

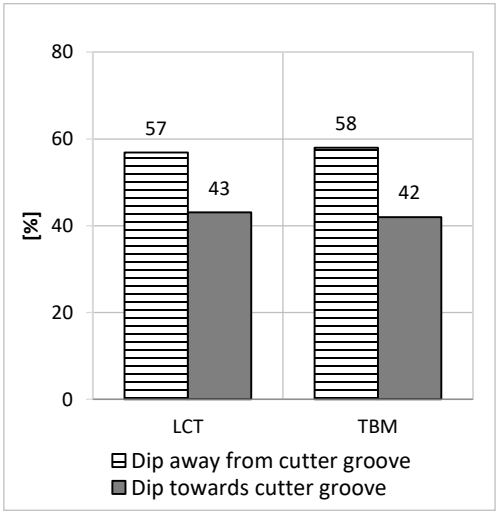
- The highest number of cracks per core sample
- The highest vertical depth of the cracks
- The longest cracks
- The most even distribution of cracks, dip angles, and dip directions in reference to the cutter groove.

LCT versus full size TBM









Main findings

- Core samples provide valuable information about the rock breaking under disc cutters
- RPM influences the rock breaking
- Rock breaking under the disc cutters of a full size TBM differs from the rock breaking under the disc cutter on a LCT

Main findings

- By use of dye penetrant and sound velocity measurements, core samples provide measureable and comparable information about cracks and fracture patterns

- The lower RPM generates a more even distribution of all properties, and the longest and deepest cracks, in both geologies

- The LCT generates a slightly optimistic result compared to the TBM

Rock breaking under rolling TBM disc cutters in hard rock conditions

- Visualization and documentation of cracks

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