Site investigation in rock masses

- Geotechnical Core Drilling & Logging
- Core Orientation
- Borehole Surveying
- Logging Core
- Borehole Log
- Face Mapping
- Scanline Data Analysis

Influence of Joints

Orientation	The stability of a block - *The type of instability*
Trace length	The extent of an instability
Spacing	The no. of blocks that will be unstable, - *The extent of instability* - *The type of instability*
Roughness (**JRC**)	The shear strength of a discontinuity - *The ability for blocks to slip*
Infill – type/thickness	The shear strength of a discontinuity - *The ability for blocks to slip*

CORE ORIENTATION

Need the orientation of the discontinuities relative to the orientation of a known feature

- e.g. to the bedding?

May need:

- closed circuit television (CCTV)
- an impression packer containing a soft rubber that takes an imprint of the core
- Craelius or Ballmark core orienter
- acoustic borehole surveying

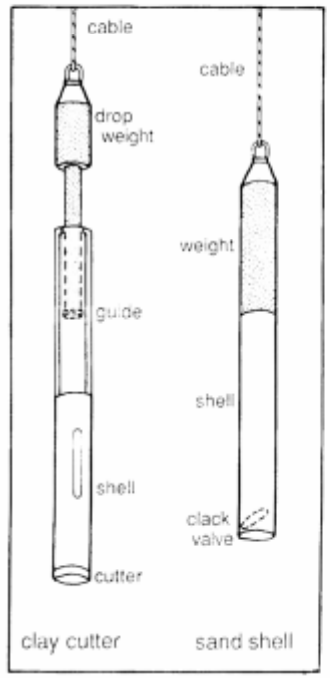
Drilling and Sampling of Rock

Exploration of Rock

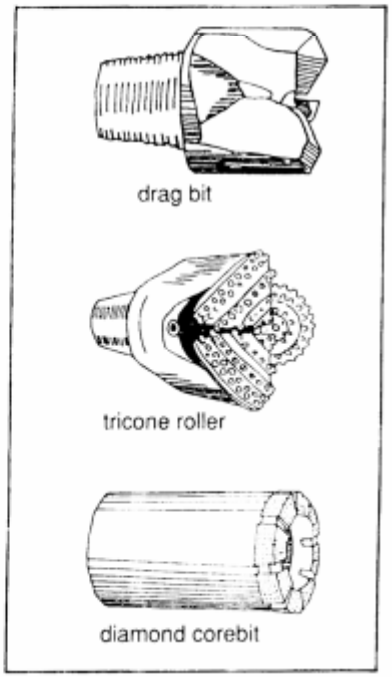
Remedial Measures for Unstable Rock Slope

Site investigation boreholes

- Percussion drilling
  - soils/soft clay rocks
  - core recovery
- Rotary coring
  - soil or rock >100m deep
  - core recovery
- Rock probing
  - rotary percussion rig
  - soil or rock
  - no core recovery



Alternative shells for light percussion drills



Alternative drill bits for rock penetration

Drilling

A standard modern diamond coring string consists of:

- drill rods in 1.5, 3 or 6 m lengths,
- a diamond impregnated or surface set coring bit
- a core barrel

"Core" is retrieved using wire line techniques

Standard diamond drill core sizes

Designation	AQ	BQ	NQ	NQ2	NX	HQ	PQ
Dia. (mm)	27	36.5	47.6	50.5	54.7	63.5	85.0

Cable (percussion) rig

Shell

Rotary rig

Core bit

Core drilling

Rock core


NORWEST HOLST SOIL ENGINEERING LIMITED
SITE HUYTON
CONTRACT F11841
No BH. 101 BOX 2
DEPTH 6.80 m to 9.60 m
9.60


DIAMOND DRILL CORE
This core was taken by diamond drilling at Penrice Marble Quarry, using a wireline core barrel similar to the demonstration model shown above. This drill core has been placed into the core tray by the driller, using the "systematic core display method".
14·25
CORE LOSS 17·25-18·03
LOSS CIRCULATI
9 3 2006

Exploration of Rock

- Investigative Methods:
  - Geophysical Methods (Chapter 5)
  - Geologic Mapping (need qualified geologists)
  - Drilling and Coring (This section
  - Exploration test pits

Buttermilk Falls, NY

Exploration of Rock

- Refusal
  - Auger refusal
  - SPT refusal (> 50 blows per 25 mm penetration)
- Rock Coring (ASTM D 2113)
- Noncore drilling

Kauai, HI

Rock Coring Methods

- Conventional equipment or wireline
- Drill bits for cutting rock
- Different core barrels for sampling rock
- Drilling fluids and casings.
- Observations noted during drilling.
- Logging of recovery and rock quality

Rock Coring Methods

Layne Rock Drilling

Drilling and Coring Bits

- Diamond bits are the best and hardest, producing high quality core. Fastest cutting rates. Expensive
- Synthetic bits. Less expensive. Generally good quality cores.
- Tungsten carbide. Least expensive. Slower coring rates.

Drill Bits

1) Surface set coring bits

- diamonds mounted in a bit crown powdered metal matrix body that is fused to a steel shank
- as the diamonds wear, thrust must be increased to maintain penetration rate
- expensive in hard rock

Drill Bits

2. Diamond impregnated coring bits
   - synthetic diamonds distributed evenly throughout the crown; new diamonds are exposed with wear
   - more consistent & faster rates of penetration
   - require higher RPMs
   - not good in rough conditions

Types of Coring Bits

Diamond, Carbide Tungsten, Sawtooth

Carbide Type Bits

Diamond Core Bits

- Core Size: Larger better but more $
- Diamond setting: hardest vector set against the work
- Bit Profiles: Full-round, semi-round, flat crown, semi-flat
- Diamond size: relates to hardness and fineness of rock minerals
- Waterways: flushing cuttings & rock flour; Number of ports, slots, discharge direction.
- Matrix: secure diamonds & dissipate heat

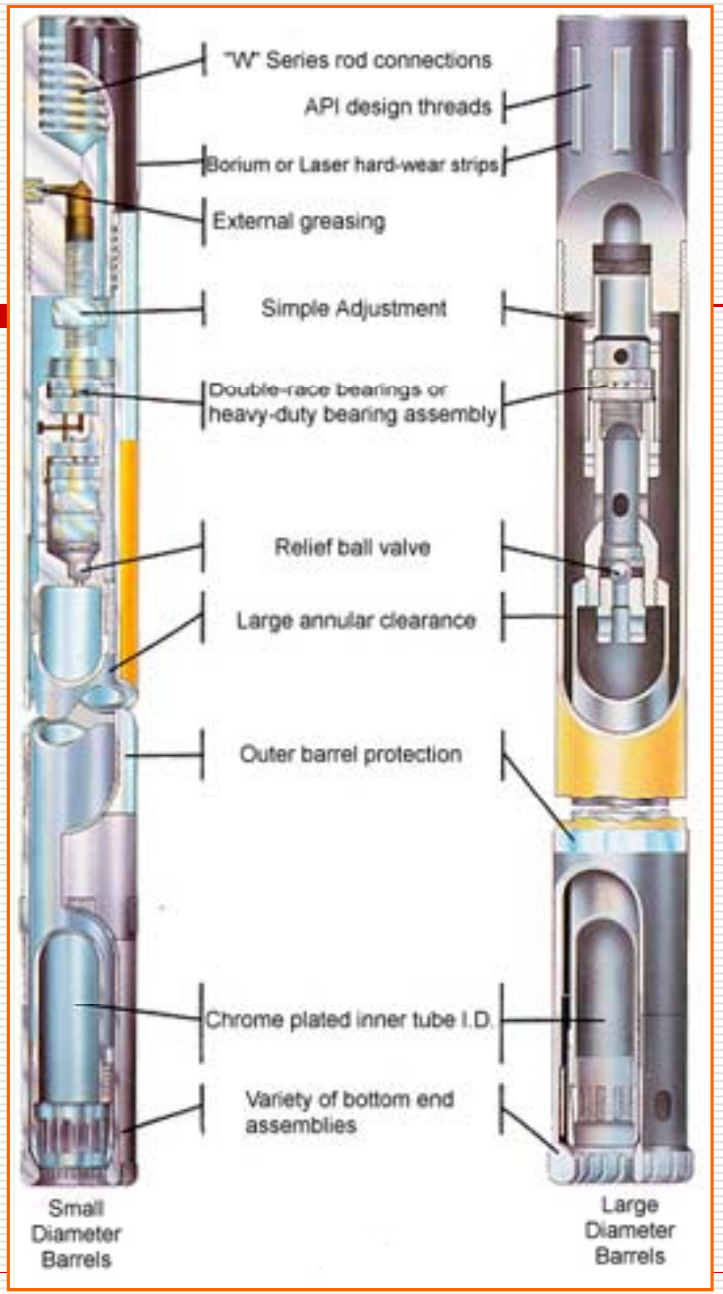
Diamond Coring Bits

www.ackerdrill.com

Core Barrels

- Core barrel retains rock core samples from drilling operations.
- Single tube core barrel: most rugged, least expensive
- Consists of head section, core recovery tube, reamer shell, & cutting bit
- Often used as starter when beginning core operations

Core Barrels



Core Barrels

- Double tube core barrel is the standard.
- Outer barrel rotates with cutting bit
- Inner barrel is either fixed or swivel type (with bearings) that retains core sample.
- Core diameters generally range from 21 to 85 mm (0.85 to 3.35 inch). See Table 3-5
- NX core: standard diameter = 54 mm (2.15 inches)

Triple Core Barrel

- Good for obtaining core samples in fractured rock and highly weathered rocks.
- Outer core barrel for initial cut and second barrel to cut finer size. Third barrel to retain cored samples.
- Reduces frictional heat that may damage Samples.

Triple Tube Assembly

- Consists of a stainless steel inner tube split lengthwise, inside a ***middle*** tube
- The middle tube is mounted on an assembly that de-couples it from the rotating outer tube & isolates the core from the drilling water
- A ***latching mechanism*** retains the middle tube in place during drilling

Triple Tube Assembly

- When the inner split tube is full, an "overshot" is run through the drill string on a wire rope to retrieve core
  - by tugging, the core in the inner tube snaps off just below a core catcher
  - middle & inner tubes are released by a latch from the outer tube, then pulled to the surface through the drill string
  - the drilling string remains in the borehole unless the bit needs replacement
- Once retrieved, the split inner tube is hydraulically separated from the middle tube

triple core barrel assembly

overshot

Latch from overshot, open & closed

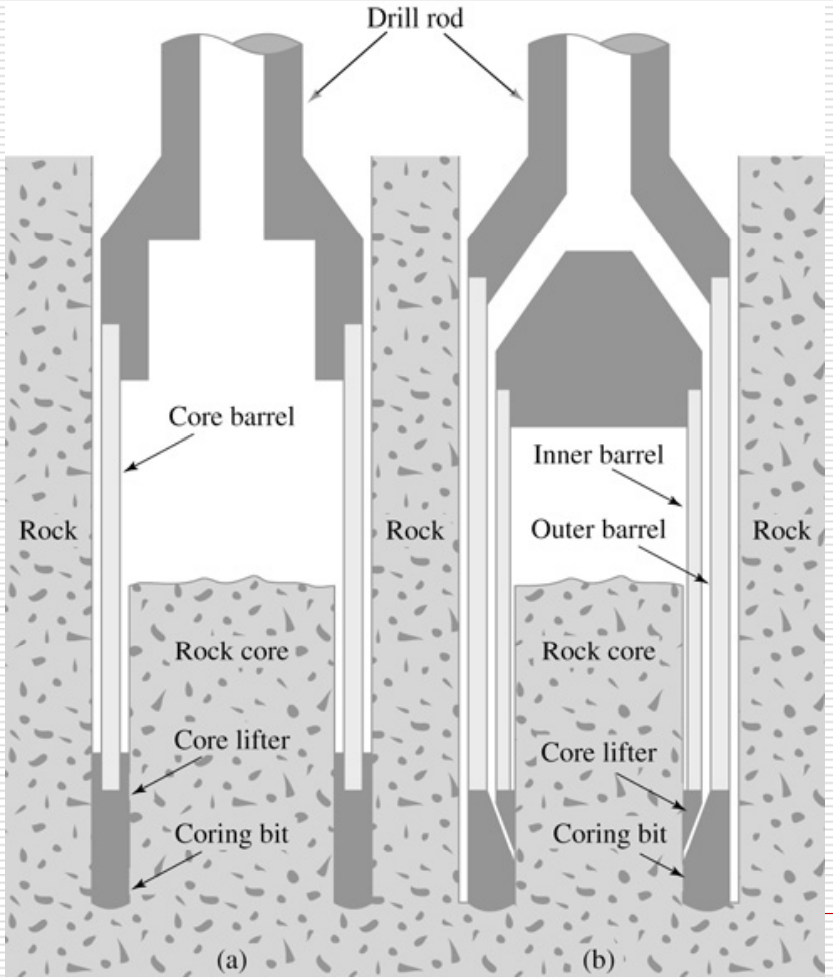
Core Barrels

Double Tube Core Barrel (Swivel Type)

Outer Barrel Assembly

Inner Barrel Assembly

Rock Coring

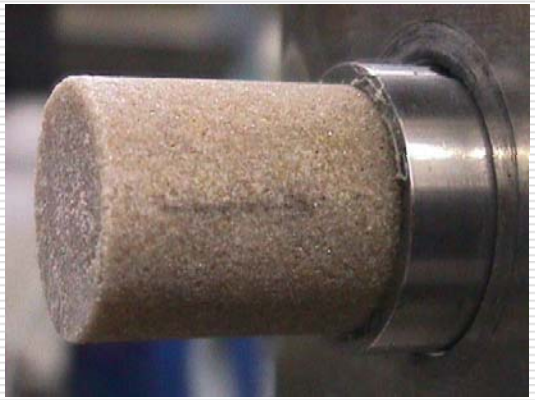


Recovery Ratio

Rock Quality Designation, RQD

Rock Coring

- Double-tube core barrel is typical
- Diamond or tungsten-carbide tooth bit
- Size of core samples varies (NX, NQ, HQ, etc.)

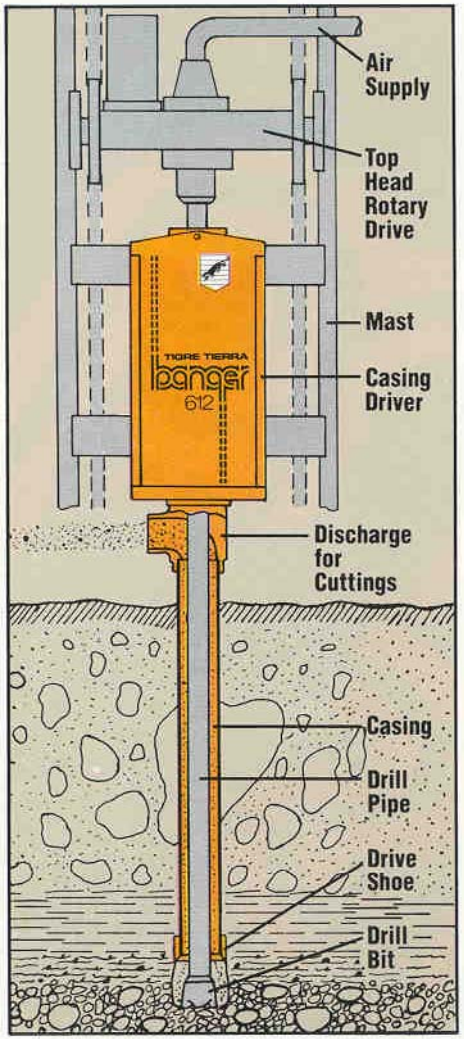


Drilling Fluids

- Rotary wash with water, foam, or drilling mud (bentonitic or polymeric slurries), Revert.
- Fluids reduce wear on drilling and coring bits by cooling.
- Fluids remove cuttings & rock flour.
- Recirculate to filter fluids and to minimize impact on environment

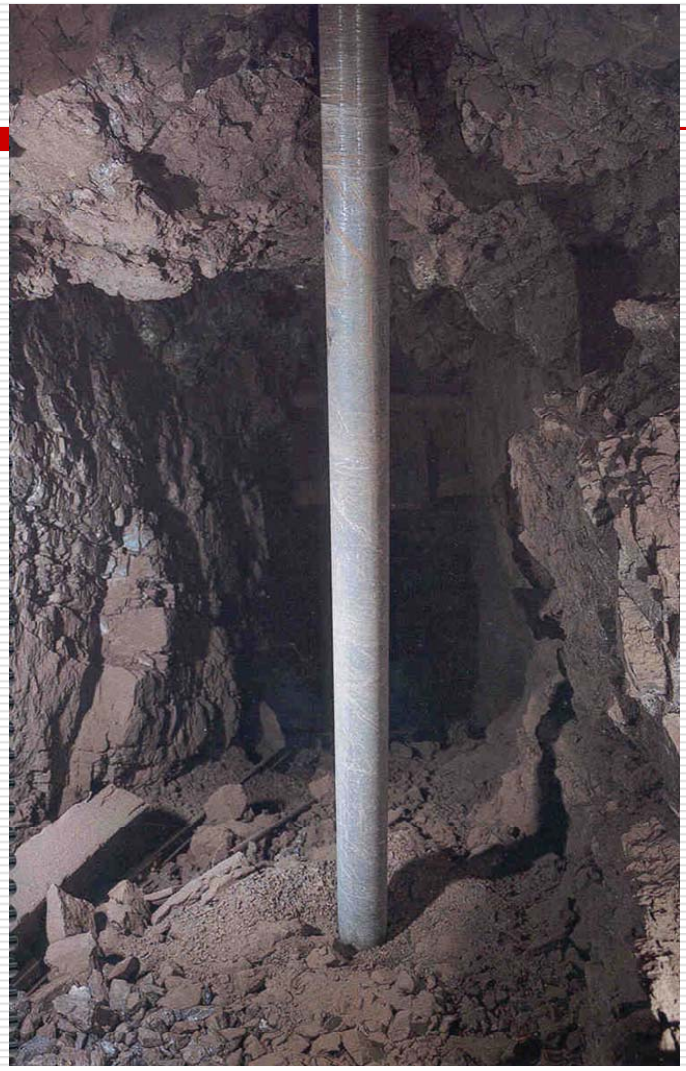
Casing

- Temporary casing to stabilize borehole and maintain drilling operations
- Driven casing
- Drilled-in casing



Dual-Wall Casing

- **Dual wall reverse circulation method**
- **Use in areas with expected large losses in drilling fluid**
- **Inner section for sampling**
- **Outer casing maintains fluids for drilling**



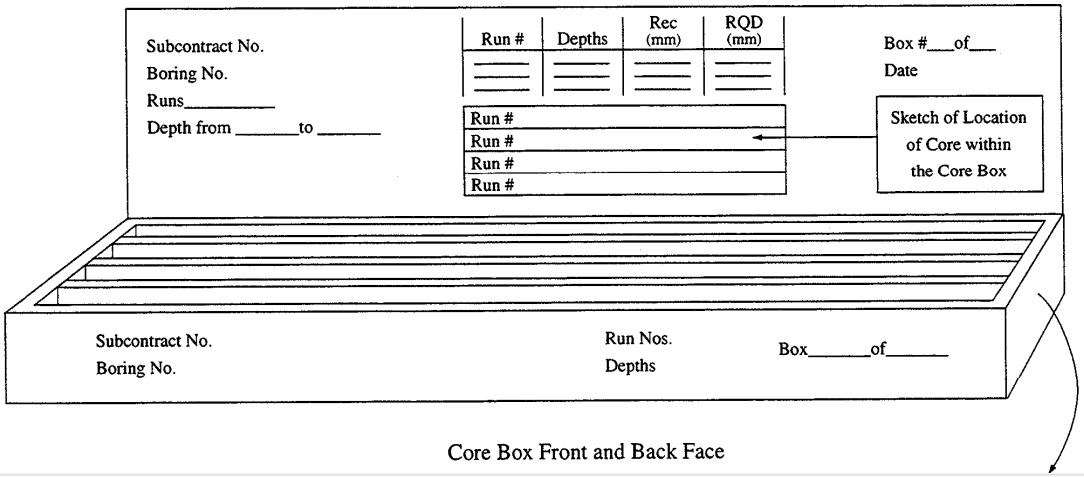
Core Recovery

- Cores should be stored in either wooden boxes or corrugated cardboard box.
- Box marked with boring number, depth of core run, type core, bit type, core recovery (CR), rock type, RQD, and other notes.
- Core operations should be documented:
  - Loss of fluid, rates, sudden drop in rods, poor recovery, loss of core

Core Recovery

- Core Runs taken in either 5- or 10-foot sections (1.5- or 3-m sections).
- Log the amount of material recovered.
- *Core Recovery* is percentage retained.

Core Recovery

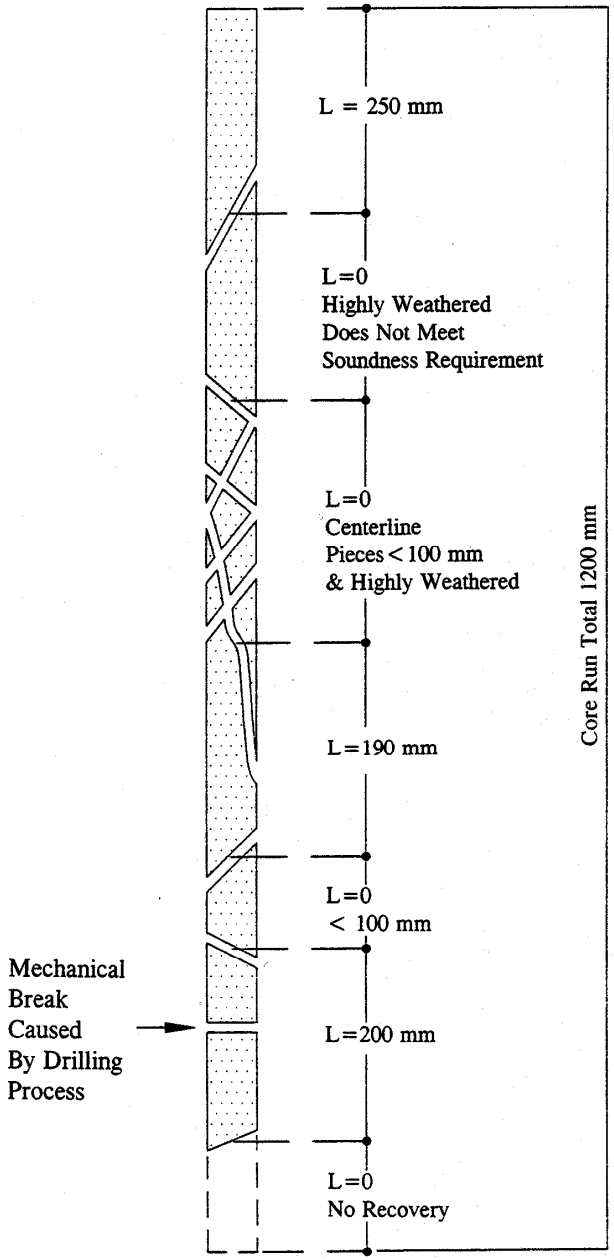


Core Box Front and Back Face

Rock Quality Designation (RQD)

- The RQD is a modified core recovery.
- Measure of the degree of fractures, joints, and discontinuities of rock mass
- RQD = sum of pieces > 100 mm (4 inches) divided by total core run.
- Generally performed on NX-size core

Rock Quality Designation



$$RQD = \frac{\sum \text{Length of Sound Core Pieces} > 100\,mm}{\text{Total Core Run Length}}$$

$$RQD = \frac{250 + 190 + 200}{1200} \times 100\%$$

RQD = 53% (Fair)

Rock Quality Description

RQD (Rock Quality Designation)	Description of Rock Quality
0 - 25%	Very Poor
25 - 50%	Poor
50 - 75%	Fair
75 - 90%	Good
90 - 100%	Excellent

Care & Preservation of Rock Cores

- Routine: rock samples in core boxes
- Special: enclose core in plastic sleeves
- General: avoid exposure to shock and vibration during handling and transport.
- Non-natural fractures may result from excessive movements, temperatures, and exposure to air.
- Storage for future reference

Storage of Rock Core Boxes

Address http://www.ballmark.com.au/

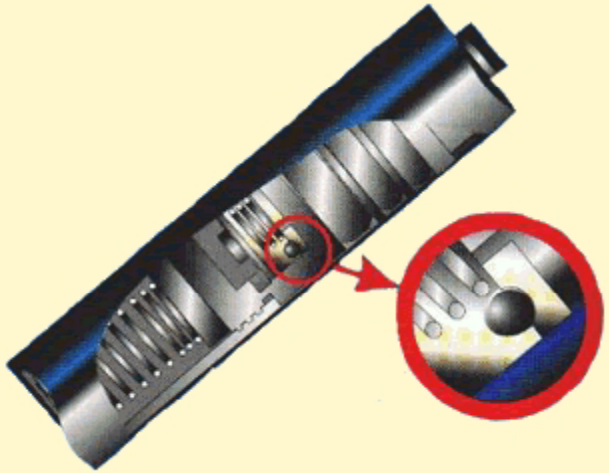
BALL MARK®

CORE ORIENTATION

- What is Ballmark?
- Why Choose Ballmark?
- Ordering Ballmark
- Who uses Ballmark?
- Contact Us

"BALL MARK"®
Is

Ballmark - The Core Orientation System



BALLMARK®
orientating dia

BALLMARK®

BALLMARK®

BALLMARK®

BALLMARK®

- The system requires no extra maintenance.
- The system does not require extensive training to put into use.
- A permanent record (the disc) is produced
- The system is compatible with most types and sizes of coreing systems in use today

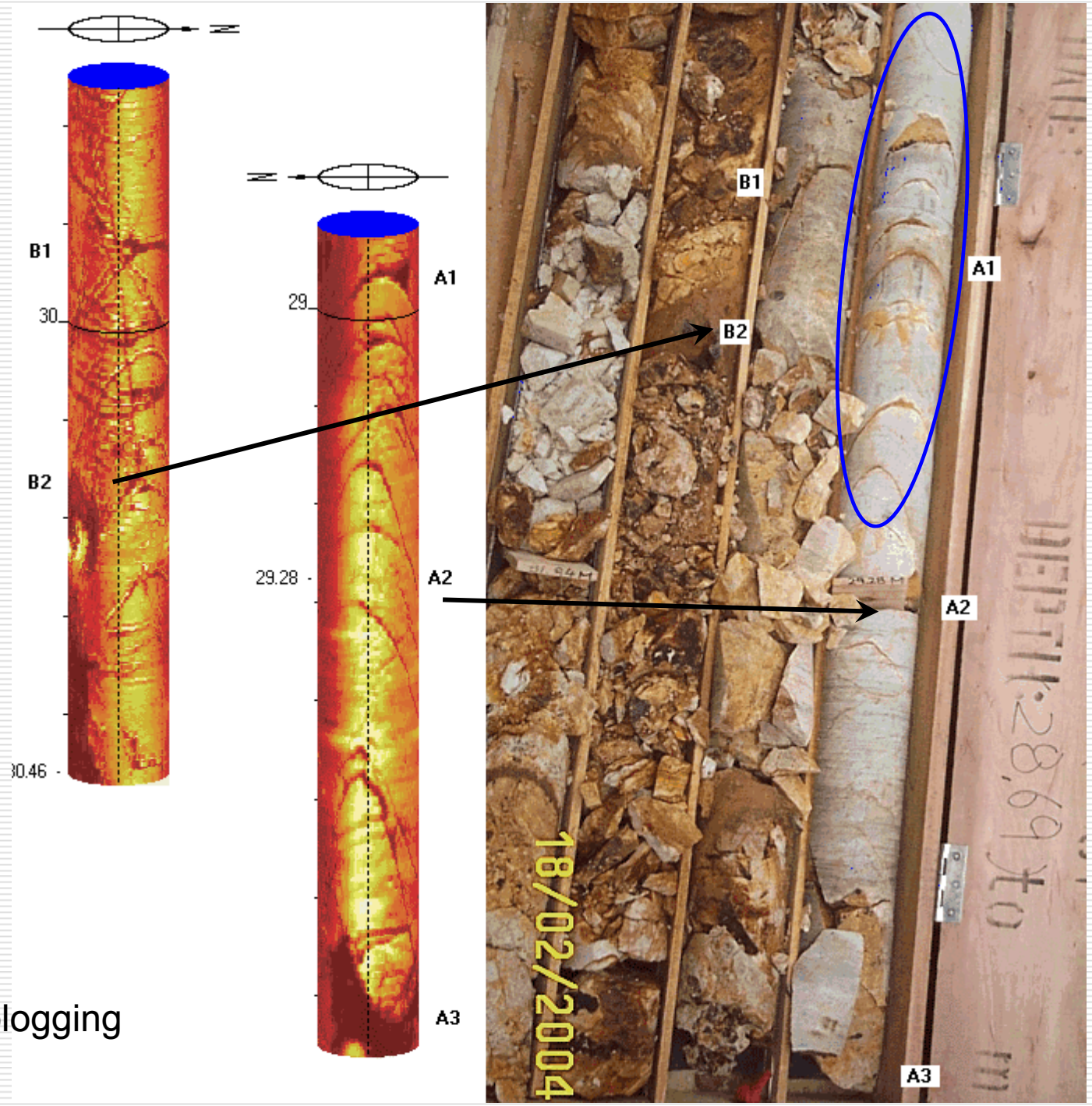
Ballmark

- **“Creates the orientation mark as and when the core break occurs”**
- There is no 'downtime' in the drilling cycle

BOREHOLE SURVEYING

Downhole **Acoustic Televiewer©**

- a narrow focussed, rotating acoustic beam that scans the wall of the drill hole in a tight helix as the tool is raised slowly up the hole
- pulses of acoustic energy are sent towards the borehole wall, which is reflected back by the borehole wall
- $\Rightarrow$ ***dip angle, dip direction & aperture width***



geologging

LOGGING CORE – general notes

- No details should be ignored, as this log may be the only record obtained for the particular site & will be relied upon in future years
- Detailed descriptions of core logging are presented by the Geological Society (1970) & ISRM (1978)

Basic logging form (refer handout)

Logging requirements apply generally to logging of soils too

- Dates of drilling
- drilling method
- drilling machine make & model
- drilling fluid type & amount

Basic logging form

- Depth and type of casing
- Zones of severe core loss
- Problems that necessitated casing
- Fluid losses
- Bad drilling zones
- Zones of severe bit wear
- Groundwater levels & dates measured

Designating a discontinuity

1) natural (**J**)oint
2) drilling-induced (**C**)rack
3) part of a fault (**F**)ault
4) bedding (**B**)edding

Identify which set (**S#**) the discontinuity belongs to? e.g. **J1** from **S1**

Intact Material Strength

- Point load testing on site, I_{s50}

  (***later lecture***)

- I_{s50} is correlated to the **uniaxial compressive strength** (UCS)

- Strength grade of rock from UCS & AS1726 (1993) handout

  e,.g. low, medium

Total Core Recovery (R)

$$R = \frac{\text{Summed length of core recovered}}{\text{Length drilled}}$$

Depends upon:

- quality of the rock mass?
- stability of / lack of vibration in, the drill rig
- choice of core barrel / skill of the operator

Infill

- thickness
- type of infill material

  (e.g. clay, ground up host rock, chlorite)

Orientation

The orientations measured from core tend may not be very reliable - scanline surveys on exposed rock are better

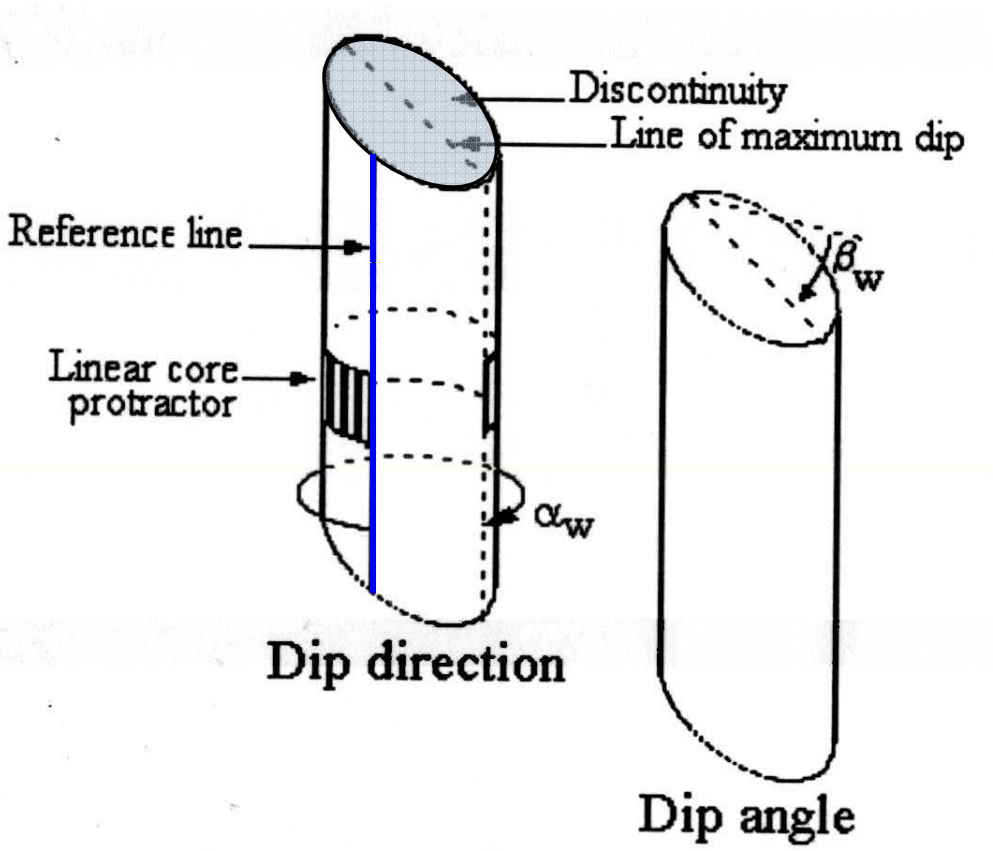


Figure 6 Measurement of orientation in oriented core.

Roughness

- Refer AS1726-1993 handout

Spacing (S)

- measure length (L) along the core axis between adjacent features and note the acute angle (β_w) that these features make with the horizontal plane

Discontinuity Frequency (λ)

- the number of natural discontinuities ***per metre of core***
- discontinuity frequency,

$$\lambda = S^{-1}$$

Rock Quality Designation (RQD)

$$RQD = \frac{\Sigma x_i}{L}$$

x_i = lengths of individual pieces of core ≥ **10 cm**

L = the total length of the drill run

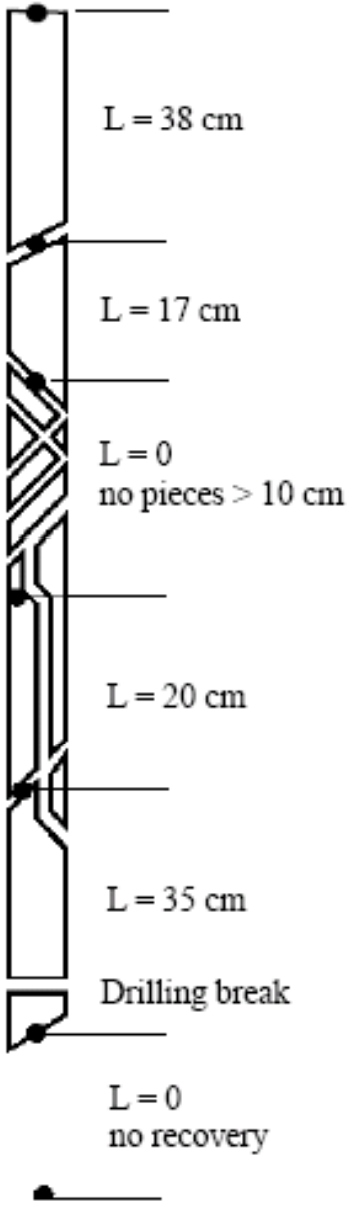


Figure 4.1: Procedure for measurement and calculation of *RQD* (After Deere, 1989).

From Chapter 4 of E. Hoek's book *online* @RocScience

FACE MAPPING

- Scanline Surveys of exposed faces
  - ***The role of the structural geologist***
- Cloth tape is attached at waist height to the rock face
- Data systematically collected on *every* natural discontinuity that intersects the tape

  which has a length > minimum length

Scanline Survey

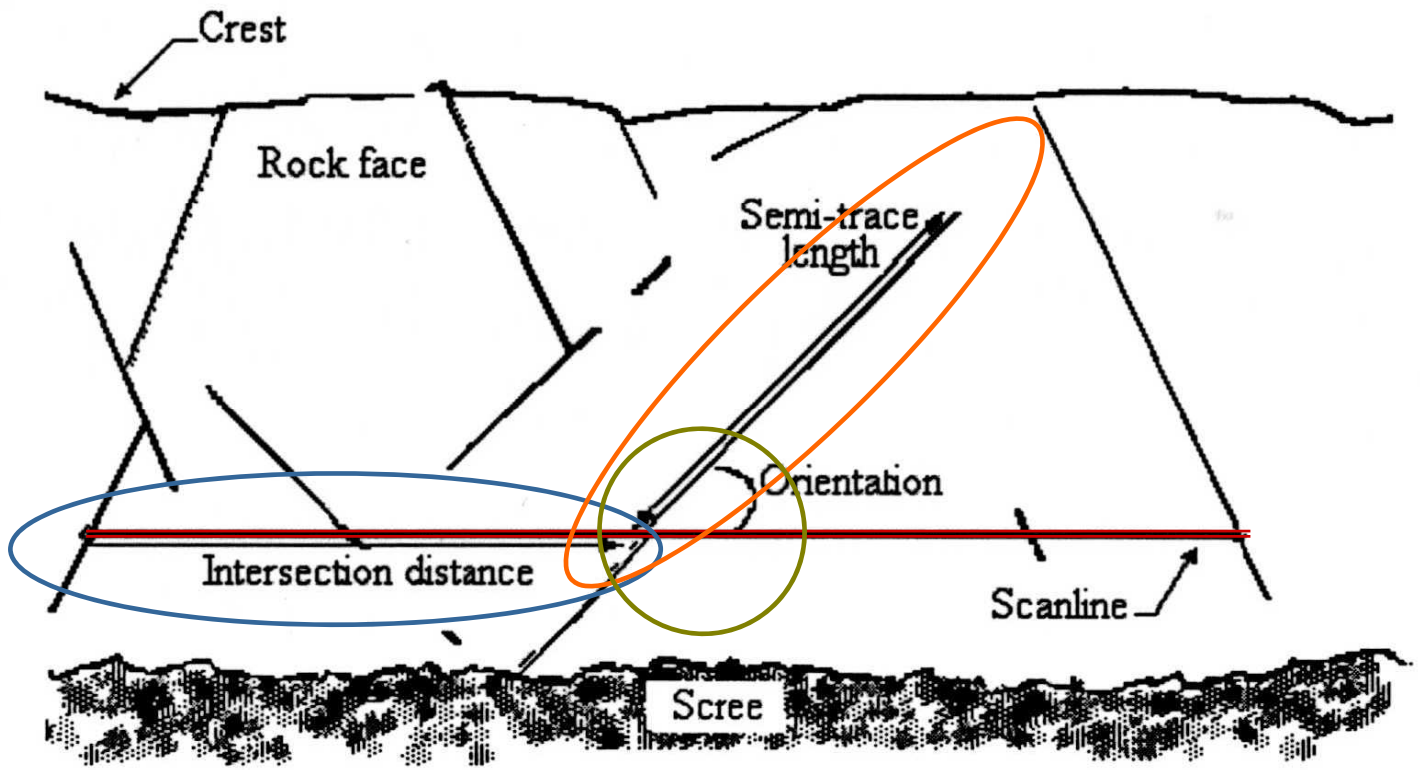


Figure 8 Schematic of a scanline survey

Data requires statistical analysis

SUMMARY of Key Points

- Drilling method – diamond cutters/water
  - Information only (non-assessable)
- Logging requirements
- RQD v R, S and λ
- Orientations from
  - Borehole instruments
  - Acoustic viewer
  - Scanline survey

References

http://geosystems.ce.gatech.edu/Faculty/Mayne/papers/NHI%202002%20Subsurface%20Investigations.pdf

SECTION 3.2 Exploration of Rock

Manual on Subsurface Investigations

National Highway Institute
Publication No. FHWA NHI-01-031
Federal Highway Administration
Washington, DC

Geotechnical Site Characterization

July 2001

by Paul W. Mayne, Barry R. Christopher, and Jason DeJong

Boart Longyear catalogue

Hard Rock Coring		
8	25231	Spindle Assembly
9	43513	Shut-off Valve
10	25233	Valve Adjusting Washer
11	24528	Ball Thrust Bearing
12	24312	Hanger Bearing
13	25234	Spindle Bearing
14	24529	Compression Spring
15	24530	Self Locking Nut
16	40678	Inner Tube cap Assembly (consists of 17, 18, 19 and 20)
17	17447	Hydraulic Grease Fitting
18	25307	Stainless Steel Ball
19	40401	Inner Tube Cap
20	37382	Check Valve Body
21	54695	GEO Inner Tube Extension
22	25238	Stop Ring
23	25239H	Core Lifter
24	25237	Core Lifter Case
25	25258	Inner Tube, 5 ft.