Rock Core Logging For Engineering Purposes

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1 Requirements of a Borehole Log

"A borehole log should provide an accurate and comprehensive record of the geological conditions encountered together with an other relevant information obtained during drilling."[1]. To which should be added that "the accurate and comprehensive record" should use clear terminology that is unambiguously defined. The purpose of these notes is to help you achieve that goal. Appropriate sources for such definitions include:

- Australian Standard Site Investigation Code AS1726-1993[2],
- Rock Characterization Testing and Monitoring – ISRM Suggested Methods 1981 [3] and
- Logging of Rock Cores for Engineering Purposes by the Geological Society[1].

Much of the information you will require is summarised in the AusIMM Field Geologists' Manual [4]

The primary borehole log may consist of a traditional paper log, a computer coding sheet or a composite paper log with imported geophysical data. Some sample logs are attached at the end of these notes.

The information to be recorded can be summarized as:

1.1 Basic information

- Project name and geographical location
- Borehole location as coordinates - include the geographical datum
- Those responsible for the borehole e.g. principal, contractor, logger
- Relevant dates e.g. date started drilling, date finished drilling, date of water level reading.

1.2 Drilling Method and Progress

- Machine
- Core barrel and bit should be described
- Details of core sizes and changes, use of casing, use of drilling fluids
- Penetration rates
- Groundwater observations while the hole is being drilled including standing water levels and water losses

1.3 Description of Type and Condition of Material Encountered

- Rock type
- Strength
- Weathering
- Defects
- Structures

1.4 Pictorial Log

Using symbols/graphs is effective shorthand in drill core logs and helps with later correlation.

Geological map symbols should conform where possible to standards published by Geoscience Australia, or more conveniently, as presented in the Field Geologists Manual [4].

2 Rock Substance Description

2.1 Rock Type

The number of different rock types that are encountered in coal basin environments is generally small and can usually be reduced to: conglomerate, sandstone, siltstone, mudstone, claystone and coal ± intrusive rocks in the form of dykes or sills.

Sometimes you will encounter entrenched (even if wrong) local terminology. For example, strictly mudstone consists of both clay and silt sized particles, siltstone mainly silt, claystone mainly clay. Shale is characterized by its fissility and compositionally may be a mudstone, siltstone or claystone. However usage is not always so precise.

Be on the look out for tuff, often it will have the appearance of a mudstone or claystone.

2.2 Colour

The colour of the rock should be described in the moist condition using simple terms such as – black, white, grey, red, brown, orange, yellow, green or blue.

Borderline colours should be described as combinations like ‘red-brown’ not ‘reddish brown’.

Colour intensity may be described as pale (not light), dark or mottled [2].

2.3 Grain size

Grain size refers to the average dimension of the mineral or rock fragments. A classification is given in Table 1.

Table 1 Particle size classification

Classification	mm
Boulders	>200
Cobbles	60-200
Coarse gravel	20-60
Medium gravel	6-20
Fine gravel	2-6
Coarse sand	0.6-2
Medium sand	0.2-0.6
Fine sand	0.06-0.2
Silt, clay	<0.06

Source: [2] and [3]

2.4 Texture and fabric (or structure)

The texture and fabric of a rock specifically refers to the arrangement of the constituent grains or crystals in a rock. It can provide an indication of how the rock formed. For example:

- In sedimentary rocks bedding indicates depositional conditions
- In igneous rocks texture indicates the rate of cooling
- In metamorphic rocks the foliation indicates stress conditions

Table 2 lists some common structures in sedimentary rocks and in Table 3 definitions of stratification and splitting terms are given.

Table 2 Common structures in sedimentary rock

Stratification (Planar)	Stratification (Irregular)
Bedding	Washout
Cross bedding	Slump Structure
Graded bedding	Shale Breccia
Lamination	Mud Cracks
Cross Lamination	

Source: [5]

Table 3 Stratification spacing and splitting terms

Bedding Term	Splitting Term	Thickness (mm)
Extremely thickly bedded	Massive	>6000
Very thickly bedded	Blocky	2000-6000
Thickly bedded	Moderately blocky	600-2000
Medium bedded	Slabby	200-600
Thinly bedded	Moderately slabby	60-200
Very thinly bedded	Flaggy	20-60
Laminated	Moderately flaggy	6-20
Very thinly laminated	Fissile	<6

Source: [1] and [3].

3 Core Recovery Measurements [1]

The fundamental unit of core drilling is the core run. This is the distance drilled from one removal of core from the barrel to the next. Normally a run will extend for the full length of the core barrel (usually 3 m). However, for a variety of reasons, usually because the drill bit is clogged and is not cutting the in situ rock, the driller may terminate a core run short of the full length of the barrel.

The materials that pass up into the core barrel may be divided into four parts:

- Solid core pieces 100mm or more in length, called **sticks**
- Solid core less than 100mm length, called **pieces**
- **Fragments** of core (i.e. not full cylindrical sides)
- Additional materials that may have been lost from previous core runs including:
    - The core stump left from the previous run.
    - Material dropped from the core barrel during its previous withdrawal
    - Cuttings that settled when circulation of drilling fluid was stopped;

Core material may also have been lost by erosion of soft, friable, or intensely fractured zones, resulting in a reduction in diameter or length of the core, or both. The eroded material may be entirely removed by the flushing system as chips.

3.1 Procedure

Draw a reference line along the core when it is first examined in the splits. All the material in the splits is defined as the **total core recovery** or TCR. Material that is recovered as solid core pieces at full diameter is defined as the **solid core recovery** or SCR. TCR will only equal SCR if there is no fragmented material in the run.

Record the TCR as a length; general practice is to ignore any fine cuttings that settled from the drilling fluid. In the final log, recoveries will be expressed as a percentage, relative to the core run length.

Check with the driller for reasons for core losses. He may have noted the depth range over which the barrel dropped or where a broken zone was intersected. Alternatively, possible zones of loss may be identified later from geophysical logs.

You should note any significant reduction in core diameter.

Stub material may be recovered in the next run and if you are examining multiple runs of core then you can make the correction at this stage. However purists will argue that you should record stub material as a loss in the first run and if it is recovered in the next run it should be included in the length of core recovered in the second run.

If you cannot identify the likely depth of core loss you should record the loss as occurring at the end of the run.

4 Rock Quality Designation (RQD)

RQD was introduced by Deere [5] as a way of correlating natural fracturing intensity with engineering performance of a rock mass. RQD measurements are based on the core run.

$$\text{RQD} = \frac{\sum \text{length of core sticks} \geq 100\text{mm long}}{\text{Run Length}} \%$$

However, the ISRM [3] suggest “that RQD values are determined for variable rather than fixed lengths of core run. Values of individual beds, structural domains, weakness zones etc. should therefore be logged separately, so as to indicate any inherent variability, and provide a more accurate picture of the location and width of zones with low or zero RQD values.”

“Material that is obviously weaker than the surrounding rock such as over consolidated gouge is discounted, even if it appears as intact pieces that are 10 cm or more in length.”

“The length of individual core pieces should be assessed along the centre line of the core, so that discontinuities that happen to parallel the drill hole will not unduly penalize the RQD values of an otherwise massive rock.” ([3], p47).

An example of the calculation of RQD is shown in Figure 1.

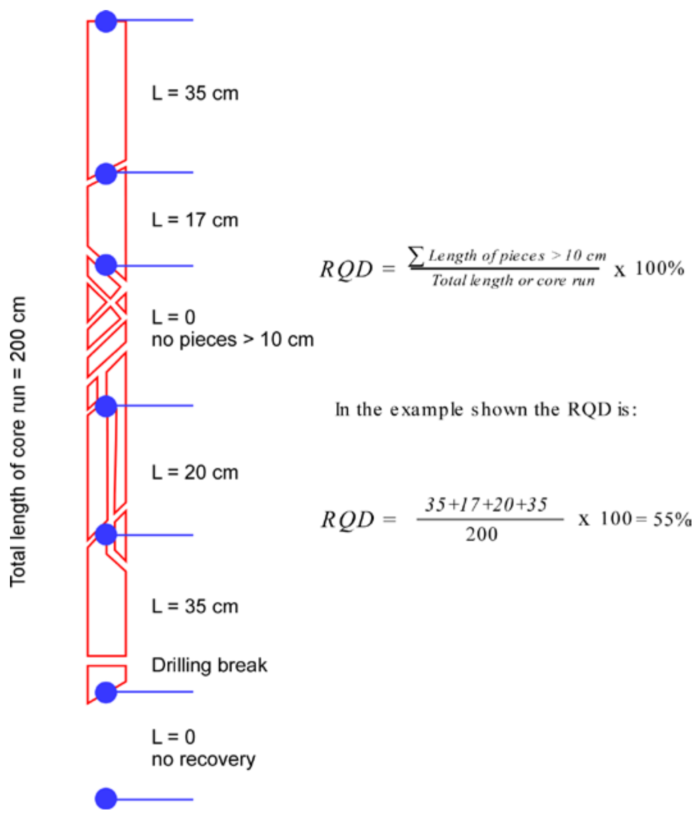

Figure 1 Example of how to calculate RQD

Deere [5] also introduced a description of rock quality based on RQD. This classification shown in Table 4 was a simple classification introduced when none other existed and if used carefully can still be found useful.

Table 4 Deere's classification of rock quality

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

5 Fracture Frequency

An alternative and complementary measure of rock quality is fracture frequency. For this, count and record the number of fractures for each metre interval of core and record the value as a number or graph of fractures per metre.

RQD and fracture frequency values may be complemented by the descriptors given in Table 5.

Table 5 Classification of core breakage

Classification	Description
Solid core	One stick
Solid core sticks	Most sticks >200mm long
Broken core	Most pieces 60mm – 200mm long
Very broken core	Most pieces 20mm – 60mm long
Fragmented core	Most pieces <20mm long
Disced core	Core broken into short flat discs

6 Rock Strength Classification

The simplest and most meaningful index of strength is Uniaxial Compressive Strength (UCS). This is determined in a laboratory. Great care must be taken to ensure that samples remain at field moisture content before being tested. Samples should be taken within 5 minutes of core being recovered, enclosed with moisture proof wrapping, and stored carefully before being tested in a timely manner. If this level of care is not taken then the samples will dry out and give test results that indicate strengths much higher than they really are.

Another alternative testing technique measures Point Load Strength. This test is often performed at the drill site as the core is being recovered.

Point Load Strength Index (Is_{50}) is correlated to UCS, but the correlation is site specific and varies with the actual rock strength.

An alternative, field-based correlation can be used to grade rock material into strength classes using the criteria shown in the right hand column of Table 6. With experience and calibration from test results, field assessment can be very reliable.

Table 6 Rock Strength Classification

Code	Strength Classification	UCS (MPa)	Field criteria
R1	Extremely low strength	< 1	May be broken by hand and remoulded (with the addition of water if necessary) to a material with soil properties.
R2	Very low strength	1 - 5	Very weak rock. Crumbles under a single firm hammer blow. Can be peeled with a knife.
R3	Low strength	5 - 10	Moderately weak rock. Breaks under a single firm hammer blow. Scored with a knife (but not peeled). Core 50mm diameter x 150mm long breaks by hand.
R4	Medium strength	10 - 25	Moderately strong rock. Breaks under 1 to 3 hammer blows. Can be scratched (but not scored) with a knife. Core 50mm diameter x 300 mm long is very hard to break by hand.
R5	High strength	25 - 50	Medium strength rock. Breaks under 3 to 5 hammer blows. Hard to scratch with a knife but steel leaves mark on core. Can be scratched with tungsten tipped scratch tool. Hard sound when hit with a hammer. Intact core cannot be broken by hand.
R6	Very high strength	50 – 100	High strength rock. Breaks under 1 hammer blow if resting on solid surface. Cannot be scratched by a knife. Can be scratched with difficulty by tungsten tipped scratch tool. Dull ringing sound when hit with hammer.
R7	Extremely high strength	> 100	Very high strength rock. Difficult to break with a hammer even if resting on a solid surface (observe safety precautions to avoid injury from shards). Bright ringing sound when hit by hammer.

Source: CoalLog manual 2012

7 Soil Strength/Density

The way soil strength is evaluated depends on whether the soil is:

- cohesive (clayey) or
- cohesionless (sandy).

When a soil material is a mix of cohesionless and cohesive components (e.g. sandy clay) its engineering behaviour is cohesive (clayey) when the clay component exceeds about 25%.

Table 7 Cohesive Soil Strength Classification

Code	Strength Classification	Su (kPa)	Field Assessment of Strength
C1	Very soft	< 12	Extrudes between finders when squeezed in hand (use Pocket Penetrometer, PP)
C2	Soft	12 - 25	Can be moulded by light finger pressure (use PP)
C3	Firm	25 - 50	Can be moulded by strong finger pressure (use PP)
C4	Stiff	50 - 100	Cannot be moulded by fingers, can be indented with thumb (use PP)
C5	Very stiff	100 - 200	Can be indented only by thumb-nail (PP use becomes marginal)
C6	Hard soil	> 200	Can only be indented with difficulty by thumb-nail, peels readily with knife (use UCS)

Source: CoalLog manual 2012

Table 8 Cohesionless Soil Strength Classification

Code	Description	Relative Density (%)	Interpretation
S1	Very loose	≤ 15	Awkward to walk, feet slip. SPT 0 – 4, Scala penetrometer <= 3blows/100mm
S2	Loose	> 15 ≤ 35	Uncomfortable to walk quickly as feet slip, SPT 4 – 10, Scala penetrometer 3 – 5blows/100mm
S3	Medium Dense	> 35 ≤ 65	Comfortable walking, footprint <15mm deep, SPT 10 – 30, Scala penetrometer 5 – 8blows/100mm
S4	Dense	> 65 ≤ 85	Firm walking, footprint <5mm deep, SPT 30 – 50, Scala penetrometer >8blows/100mm
S5	Very dense	> 85	Hard surface, footprint indentation minimal SPT >50, Scala penetrometer not recommended

8 Weathering

The recommended weathering classification is shown in Table 9. It is from the Site Investigation Code AS1726 1993 [2].

In the previous edition of the Site Investigation Code the DW classification was subdivided as shown in Table 10 and some people still use this. The problem with this is that the descriptors given in Table 10 imply that rock become weaker as it weathers when, in fact it may become stronger when, for example, ferri-oxides are deposited. The boundary between soil and rock is defined by a material's strength and not by its degree of weathering.

Even though many people think they know what they mean by "highly weathered" and moderately weathered" usually this cannot be objectively defined and replicated by another person. So these terms should be abandoned in this context.

It is much better to be approximately and consistently right than precisely wrong.

Table 9 Weathering Classification from AS1726-1993

Code	Classification	Description
W	Weathered	Degree of weathering not assessed
RS	Residual Soil	Soil developed on extremely weathered rock, with texture and fabric no longer evident. Large reduction in density. Only used when a reasonable geological inference that the soil is derived in situ from the weathering of rock, and has not been transported or reworked in any manner.
XW	Extremely Weathered	Original rock texture and structure evident but decomposed to a friable or plastic condition. Can be remoulded and classified as a soil
DW	Distinctly Weathered	Original rock material strength changed by weathering. Highly discoloured, usually iron staining. Porosity may be increased or decreased
SW	Slightly Weathered	Original rock slightly discoloured but little or no strength change from fresh rock. Usually penetrative weathering along defect surfaces
FS	Fresh Stained (Non-AS1726)	Rock is fresh and unchanged from original except for mm wide staining along some joints
FR	Fresh Rock	Rock shows no sign of decomposition and staining. No change from original condition

Table 10 Weathering Classification from AS1726-1981

Code	Classification	Description
HW	Highly Weathered	Shows considerable change in appearance and loss in strength. Material is still a rock but normally very weak.
MW	Moderately Weathered	Visible change in appearance but no significant loss in strength.

9 Slaking

The Emmerson Crumb test is described in Australian Standards AS1289 [7], however the recommended measure of slaking is the Godfrey Slaking Grade. This is believed to have been developed by Nigel Godfrey as part of his master's degree research based in the Bowen Basin during the 1980s and because people have found it so useful it has entered into widespread usage although it has not been formally published.

The Godfrey Slaking Grade can be evaluated during logging by adding small lumps (5mm to 20mm) to a container of clear water and observing the reaction over a period of 5 minutes.

Table 11 Godfrey Slaking Grade

Code	Classification	Observations
G0	No slaking	No visible action. Water remains clear
G1	Edge fall off only	Water remains clear. No further action after initial spall-off around knock points and edges
G2	Slow surface slaking	Water remains clear. Slight to mild surface and edge slake-off within 3min. Surface appears slightly softened and swollen sometimes. No further action
G3	Medium Slaking, No Colloid	Spall-off and slake to a fissile flake pile, tabular and sheet-like. Little or no visible swelling. No colloidal cloud. Core of original specimen often preserved as a series of upstanding flakes.
G4	Rapid Slaking, No Colloid	Immediate slake-down to a shapeless pile of smallish flakes with some swelling and moderate flocculation to some areas. No colloidal cloud.
G5	Rapid Slaking, Some Colloid	Fast slake-down to a shapeless pile of small crusts and flakes. Often gel-like, colloidal, puffy flocculations. Thin, weak colloidal cloud. Moderate effervescence.
G6	Rapid Slaking, Swelling, Thick Colloid	Rapid and violent slake-down and swelling with much effervescence. Marked swelling and gel-like flocculations with quite a thick colloidal cloud.
G7	Extremely Rapid Slaking, Gelled, Thick Colloid	Extremely rapid and often violent break-up to a swollen amorphous pile of jelly-like consistency with rapid colloidal cloud spread.

Godfrey, N., A Field Recognition Guide to Swelling Clay Rich Weathering Profiles in Overburden Sediments in the Northern Bowen Basin. *"Sediments Through the Ages" Proc 5th Australian Geological Convention*, Perth, W.A. Geological Society of Australia Inc.

10 Defects (Tectonic Structure)

Observing and recording defect information is a critical task since the defects control the engineering behaviour of the rock, rather than the rock substance itself.

When logging rock cores you need to have in mind that:

- Drilling usually causes some disturbance of defect surfaces or filling.
- There is only a limited extent of any defect surface exposed in a core interval (e.g. am I looing at cross bedded sandstone or horizontal beds disturbed by nearby faulting?)
- Core drilling gives no information at all on the extent of a defect surface, whether its orientation changes with distance, and what happens when defects intersect outside of the core. (e.g. is the feature a shear associated with limited movement or a fault signifying a substantial displacement?)

This means that you need to be very careful about what inferences you draw and may record about what you see in the core but does not detract from the necessity to make accurate records. When in doubt, record the facts and leave the inferences for your report.

Information should be recorded about:

- The type of defect
- The spacing of defects
- Interface properties of the defect
- Orientation.

10.1 Defect Type

Table 12 lists some of the common defects that are encountered in coal measures rocks and their characteristics.

Table 12 Rock defect types

Common Symbol	Description	Description
PA	Parting	A defect parallel or subparallel to a layered arrangement of mineral grains or micro-fractures which has caused planar anisotropy in the rock substance.
BP	Bedding plane parting	The separation between bedding units, and is a critical surface observation when assessing bedding structure.
JN	Joint	Joints in rock are defined as fractures where there is no measurable slip displacement. Different styles of joint can form due to different deformational events. The common cause is extensional straining beyond a material limit.
S	Shear	Any surface that shows the characteristic signs of shearing but no measure of the amount of shear slip must be described as a shear. A shear may be a discrete local surface formed by differential compaction, a subsidiary slip surface within a fault zone, or a principal displacement surface with an actual (but not measurable) displacement of tens of metres.
Sz	Sheared Zone	A zone with roughly parallel planar boundaries of rock substance containing closely spaced, usually slickensided joints
Z	Bedding Surface Shear	Bedding surface shears occur in sedimentary rock sequences for many reasons. They are extremely important in geotechnical terms, since the often control the stability of excavations. Bedding surface shears formed by flexural slip are generally more extensive and weaker than bedding surface shears formed by differential compaction.
FA	Fault	A fault surface, by definition, can only be described if the relative slip displacement is actually measurable. A surface that has obviously undergone relative displacement (shearing) of *unmeasurable* extent is described as a *shear*.
Cz	Crushed Zone	A zone with roughly parallel planar boundaries of rock substance composed of disorientated, usually angular, fragments of rock that may be clay silt, sand or gravel sized.
A	Microfault	Microfault can *only* be used to describe a defect where very small-scale relative displacements are observed.
CE	Cleat	Cleat is a small-scale fracture within coal, often with infilling, that has very limited surface extent. When discrete fracture surfaces in coal are larger than about 30mm they should be described as joints rather than cleats.
I	Intrusive contact	This can only be interpreted if the geologist can establish from observation that an intrusion occurred. Sedimentary dykes form intrusive contacts.
VN	Vein	Is a defect formed by separation and infilling. Often, it is not possible to tell if the infilling was immediate, or followed some time after the original separation. Pressure solution effects may produce veins that are difficult to interpret.

10.2 Spacing of Defects

Measure mean and range spacings for each set of defects where possible. RQD and Fracture Frequency, described above provide an overall measure of defect spacing. Table 13 gives definitions of terminology that may be used in describing defect spacing.

Table 13 Defect spacing definitions

Definition	Tectonic Structure Spacing
Extremely widely spaced	>2m
Very widely spaced	600mm – 2m
Widely spaced	200mm – 600mm
Moderately spaced	60mm - 200mm
Closely spaced	20mm - 60mm
Extremely closely spaced	6mm – 20mm
Continuous spaced	<6mm

10.3 Interface properties

Thickness – openness – measured in millimetres normal to the plane of the discontinuity.

10.3.1 Roughness

A very commonly used descriptor of surface roughness is that based on the ISRM method. Originally this scheme was used to describe intermediate scale (several metres) roughness – stepped, undulating and planar and small scale (several centimetres) roughness –rough, smooth and slickensided. Nowadays the terminology of this method is also used in describing core scale defects.

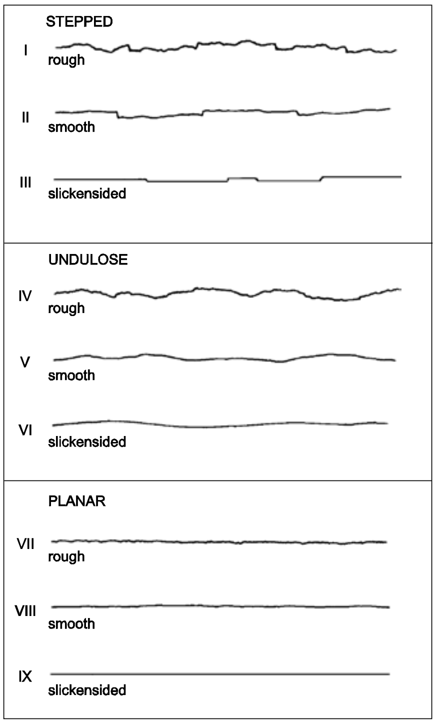

Figure 2 Typical roughness profiles and ISRM suggested nomenclature. The length of each profile is in the range 1 to 10 metres. Vertical and horizontal scales are the same.

10.3.2 Coating or infilling

Definitions of terms to describe coating or infilling are given in Table 14

Table 14 Description of rock defect coating or infilling

Term	Definition
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (less than 1 mm). If discontinuous over the plane, patchy veneer.
Coating	A visible coating or infilling of soil or mineral substance, greater than 1 mm thick. Describe composition and thickness.

10.4 Structure Orientation

The orientation of all structures should be recorded. Ensure that the convention you adopt is clearly noted. E.g. have you measured a dip value or an angle with respect to the core axis? Are your azimuth values magnetic or grid?

11 Logging of Groundwater Conditions

Groundwater conditions should be recorded for all boreholes both during drilling and on completion of drilling. All levels should be recorded from the collar and the date and time of any readings should be noted. Water make can be measured using a simple V-notch weir. The Field Geologist's Manual [4, p327] provides a weir board discharge table.

It is equally important to record that no readings were taken or that no water was observed.

One scheme for recording borehole water level observations is shown in Table 15. This scheme encompasses qualitative and quantitative observations.

Table 15 Scheme for recording water observations

Code	Observations
NM	No observations made
TW	Traces of water encountered
FW	Water level falling
RW	Water level rising
NW	No water encountered
L1	Circulation loss minor (<30%)
L2	Circulation loss major (30%-80%)
L3	Circulation loss complete (>80%)
M1	Water make minor (<0.2 l/s)
M2	Water make significant (0.2-2 l/s)
M3	Water make major (>2 l/s)

12 Taking and Caring for Core Samples

Samples are generally taken for two reasons:

- To determine the material properties of the intact rock and thus to establish a correlation with the geophysical logs e.g. relating sonic velocity to UCS, and
- To determine the shear strength of defects within the rock.

In both cases samples need to be taken as soon as the core has been extruded from the splits and certainly within 15 minutes otherwise irreversible drying out will occur, particularly in typical hot Bowen Basin/Sydney Basin weather which will have the effect of indicating strengths that may be 2 or 3 times greater than the in situ strengths.

If you can't take the samples for testing within two minutes of the core being extruded from the splits then identify where you will want to take your samples from and cover that area with a wet cloth until you are ready to take the sample.

Once you have taken your sample the following procedure will help keep the sample intact and at its in situ moisture content:

- Add a little free moisture to the sample before sealing it
- Wrap the sample in cling film – the cling film will be in close contact with the sample and will help to reinforce it but it can breathe.
- Wrap the wrapped sample in catering grade aluminium foil – this stiffens the sample and provides further sealing against moisture migration.
- Wrap grey ducting tape around the sample this provides additional sealing and protection and provides a good surface on which to write the sample details using permanent marking pen.
- If the sample is delicate or will be transported for long distance reinforce the wrapped sample with appropriately sized split PVC pipe. Duct tape the whole assembly including the ends so that the sample cannot slide out.

Aluminium foil is very useful for holding together samples that include a geological defect such as a shear whose strength you wish to determine.

While in the field, samples must be protected as best as possible from heat and should be taken back to the office each night.

In the office samples should not be kept for extended periods in an air-conditioned office as the air has a low humidity and if there is any possibility will tend to dry out the samples.

Transport the samples to the laboratory for testing as quickly as possibly. Use a core tray to provide physical protection to the samples. Pack them carefully so that they cannot move about and become damaged.

13 Core Photographs

All core should be photographed in the field while it has experienced minimal disturbance. The following guidelines are suggested:

- Photograph one box per photograph.
- If the core is dirty wash it before photographing it.
- Take photographs in natural light between 9 am and 3 pm unless you can correct for white balance (digital cameras can do this automatically and post processing in Photoshop is effective in removing colour casts). This will reduce the risk of getting distinct orange casts in your images.
- Arrange the core boxes so that sun comes from the about the same angle, usually top right. This will:
- Give a consistent appearance to your photographs
- Keep your body shadow out of the photographs
- Minimise shadows due to the core tray dividers.
- Photograph the core wet, if possible. Photographing it wet can highlight some features but it is often not possible to achieve uniformly wet core under hot, sunny field conditions.
- Position yourself so that you reduce the converging verticals effect i.e. hold the camera perpendicular to the core boxes. Use a lens with a focal length of at least 35 mm so that you minimise the curvature distortion that is characteristic of wide angle lenses. Both of these effects can be corrected using digital imaging software but this is time consuming.
- Stop down your lens to around the middle of the stop range to obtain best results. This value will typically be f8 or f11.

14 References

1 Geological Society Engineering Group Working Party, 1970. The logging of rock cores for engineering purposes. *Q J Engng Geol*, 3, 1-24.

2 Standards Association of Australia. Geotechnical Site Investigations. AS1726-1993.

3 Brown, E.T. (Ed.), 1981. Rock Characterization Testing & Monitoring – ISRM Suggested Methods, Pergamon Press.

4 Berkman, D.A. (Compiler), 2001. Field Geologists' Manual. Monograph No.9 4th edn. AusIMM, Melbourne.

5 SMEC, 1991. Geomechanics Quality Procedures Manual.

6 Deere, D.U., Henderson, A.J., Patton, F.D. and Cording, E.J. 1967. Design of surface and near-surface construction in rock. In *Failure and Breakage of Rock*, Proc. 8th Sym on Rock Mechanics. Charles Fairhurst (ed.) AIMM&PE, New York.

7 Standards Association of Australia. Methods of Testing Soils for Engineering Purposes. AS1289-2000.

15 Field Logging Sheet

There are many field logging sheets available. The attached sheet has proven to be very suitable. It separates the key elements of the log: drilling, strength, weathering and structures while keeping them all on the same sheet and thereby minimises repetition of data entry.

Proj_No:	Project:		BH_Locn:	BH_No:	Drill Co:	Rig:
Date_Start:	Date_Finish:		E:	N:	Barrel:	Fluid:
Total Depth:	Casing:	SWL:	RL:	Datum:	Driller:	Logger:

Drilling Information							Lithology		Weathering		Strength			Samples		Defect Description						
Base Depth	Run	Recovery		Loss	RQD		Base Depth	rock type, grain characteristics, colour, minor components	Base Depth	RS, XW, DW, SW, FR	Base Depth	Hd,EL, VL,M, H,VH, EH	Num Code	From	To	Depth	Type	Dip	Plan-arity	Rough-ness	In-fill	W
(m)	(m)	(m)	(%)	(m)	(m)	(%)	(m)		(m)		(m)			(m)	(m)	(m)			st,un,pl	r,sm,sl		(mm)

Comments: