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Our Ref: PSM2854-003L

2 June 2016

Compass Resources
PO BOX 37446
WINNELLIE, NORTHERN TERRITORY 0821

ATTENTION: ANDREW TONG
Via email: andrew.tong@compassresources.com.au

Dear Sir,

BROWNS UNDERGROUND PROJECT – FEASIBILITY LEVEL STUDY
STOPE SIZES

1 INTRODUCTION

This letter presents the results of studies carried out by Pells Sullivan Meynink (PSM) of stope sizes for the Feasibility Study of the Browns Underground project; a proposed underground lead mine near Batchelor, Northern Territory (Figure 1).

2 PROPOSED MINING DEVELOPMENT

The *2013 Scoping Study*(1) proposed to mine the steeply dipping 5 to 40 m wide lead and copper orebody at Browns to a depth of about 600 m by a variation of open stoping referred to as end-slice mining. Preliminary stope sizes were nominally 10 m wide, 30 m high and 50 m long accessed by a decline and drives nominally 5 m x 5 m. Cement backfill was to be used to stabilise the mined out stopes. The strike length of the proposed stope development is approximately 770 m.

A geotechnical site investigation was undertaken in October 2015 to collect the following information to address the proposed mine development:

- Deposit and host rock unconfined compressive strengths (UCS)

(1) *Browns Underground Lead Mine Scoping Study*. October 2013. Australian Mine Design & Development.

- Stress field magnitude and orientation
- Rock mass jointing count, roughness, alteration and orientation
- Rock quality designation (RQD).

Six cored boreholes were drilled and logged. The data is reported in the *Geotechnical Investigation - Factual Report*[2].

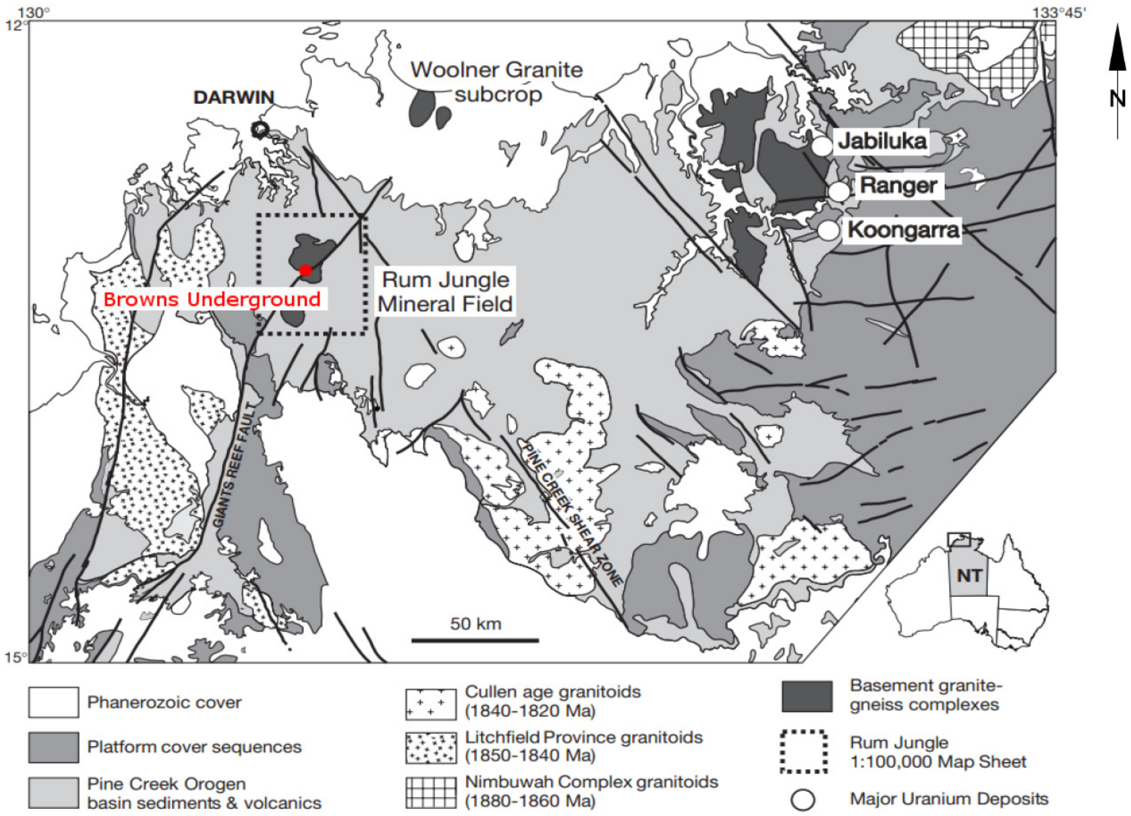

Figure 1: Regional geology[3]

3 SITE GEOLOGY

The host rocks at Browns are black carbon-rich shales, which have been subjected to low grade regional metamorphism. The shales were intruded by highly altered basalts (dolerite), which form the hanging wall to the deposit. The footwall comprises the Coomalie Dolostone, which is a shallow water stromatolitic dolomite and magnesite with minor shale partings (Figures 2 and 3).

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(2) Browns Underground, *Geotechnical investigation – factual report*, PSM2854-002R, Nov 2015.
(3) from McCready, A J, Stumpfl, E F, Lally, J H, Ahmad, M & Gee, R D, 2004. *Polymetallic mineralisation of at the Browns Deposit, Rum Jungle Mineral Field, Northern Territory, Australia*. Economic Geology, Vol. 99, pp. 257 – 277.

The Browns deposit is located on the northern limb of the Embayment syncline. The syncline is described as a gently southwest plunging fold (Reference 2). The sheet like orebody is intersected by synthetic and antithetic fault splays off the Giants Reef fault. Some of these features are shown in Figure 2.

The orebody dips steeply to the south at depth but displays gentler dips near the surface. Relict sedimentary bedding can be observed locally in the shales as can two distinct cleavages including a pervasive slaty cleavage parallel to bedding.

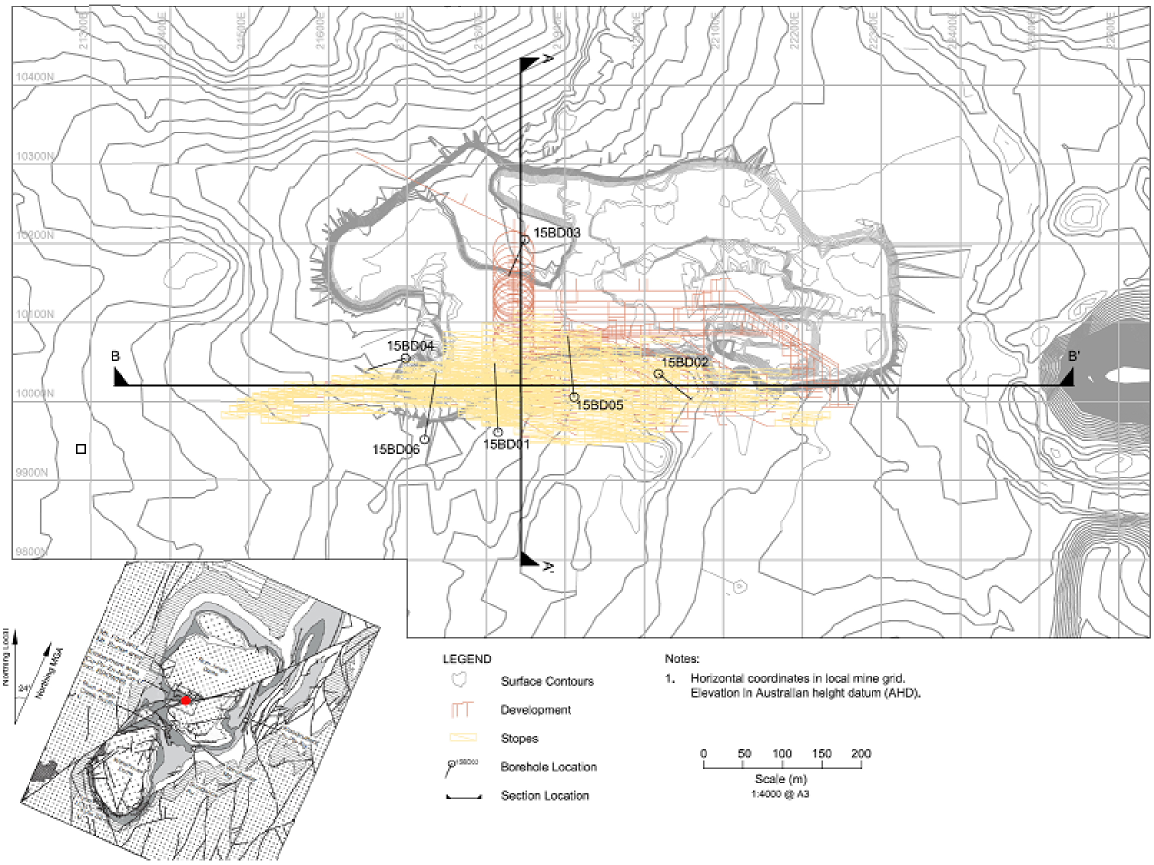


Figure 2: Plan of proposed Browns Underground

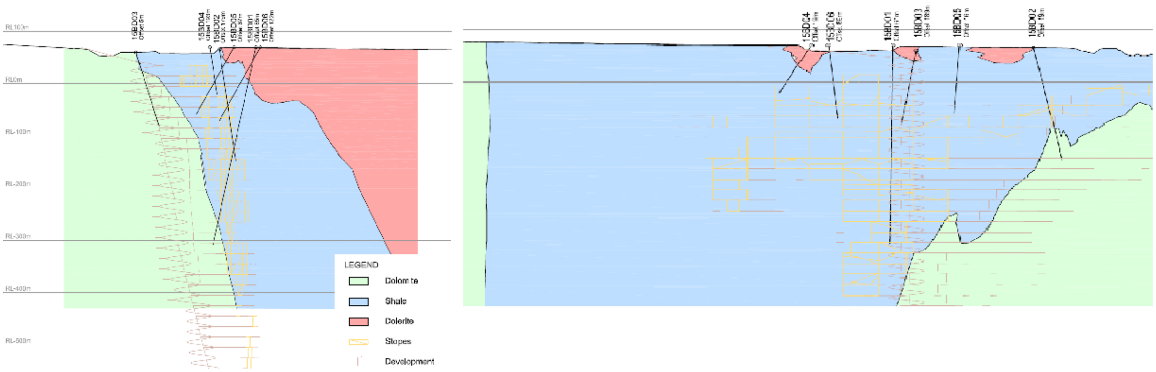


Figure 3: Sections A-A' and B-B'

4 ROCK MASS

Three rock mass units are present at Browns Underground – dolerite, shale and dolomite.

4.1 Dolerite

The dolerite hanging wall is grey to light grey, high to very high strength (average UCS = 73 MPa, range 41 – 106 MPa) rock mass.

The dominant defect set is planar, slightly rough, clean, foliation that steeply dips towards the southeast. Shears, sheared zones and fractured zones occur parallel to foliation.

4.2 Shale

The shale, which hosts the orebody and which will form the bulk of the stope walls, is grey to black, low (average UCS = 13 MPa, range 1 – 40 MPa) and medium (23 MPa, 7 – 55 MPa) strength, fine-grained rock mass. The higher strengths generally occurring adjacent to the dolerite intrusions.

Pervasive foliation is well developed throughout the rock mass. Foliation is generally is planar to undulating, smooth to slightly rough, coated with powdery graphite and steeply dipping towards the southeast, with some variation. Shears, sheared zones and fractured zones occur parallel to foliation.

Ten percent of defects were filled with rock fragment, often thicker than 100 mm. A further 7% were slickensided or polished.

4.3 Dolomite

The dolomite footwall is a massive, white and red, high to very high strength (average UCS = 62 MPa, range 30 – 143 MPa) rock mass. Dolomite boulders, commonly over 2 m^3 and up to approximately 8 m^3, are observed on the surface around the site.

Four sets of moderately dipping joints are observed in the dolomite. Most are clean, slightly rough and of irregular shape. None were slickensided or polished.

The majority of the underground development is planned to be within this rock mass.

5 IN SITU STRESS

In situ stress tests suggest:

- The minor principal stress is vertical
- The major principal stress is horizontal towards the northeast with a magnitude approximately 2.5 times the vertical stress.

6 STOPE DESIGN

At this stage of the project planning, stope design is based on empirical methods; specifically that based on the Modified Stability Number (*N'*) (Potvin, 1988). *N'* is the product of the following four parameters.

- *Q'* = (*RQD / Jn* x *Jr / Ja*)
- *A* – Rock stress factor based on the ratio of intact rock strength to the maximum mining induced stress, UCS / σ_{max}
- *B* – Joint orientation factor based on the relative orientation of the dominant joint set to the excavation
- *C* – Gravity adjustment factor.

6.1 Q'

The Q' value was assessed for each of the six boreholes included in the *Geotechnical Investigation - Factual Report*.

The *RQD* was used as recorded. The parameters *Jn*, *Jr* and *Ja* were based on the descriptions provided in the borehole logs to match those given in the Q-system (Barton, et al. 1974). These are outlined in Tables 1 and 2.

The variation of Q' along each borehole is presented as a log in Attachment A.

TABLE 1
Jr VALUES CORRELATED TO LOGGED VALUES

Jr	LOGGED VALUE
3	Defined ridges, small steps or very rough (Ro3, Ro4 or Ro5) and Curved, undulating, stepped or irregular (CU/UN/ST/IR)
2	Smooth (Ro2) and Curved, undulating, stepped or irregular (CU/UN/ST/IR)
1.5	Either Slickensided/polished and undulating or stepped (Ro1/UN, Ro1/ST), OR Defined ridges or small steps and planar (Ro3/PL, Ro4/PL)
1	Smooth and planar or curved (Ro2/PL, Ro2/CU)
0.5	Slickensided/polished and planar or curved (Ro1/PL, Ro1/CU)

TABLE 2
Ja VALUES CORRELATED TO LOGGED VALUES

Ja	LOGGED VALUE
0.75	No infill (KL)
1	Iron oxide staining (ST)
2	Fe, MG, QZ, sulphide or rock fragments < 50 mm thick
4	Clay or calcite (CA) < 10 mm thick
6	Fault, fractured zones, shear and crushed zones with rock fragment infill
10	Clay or calcite (CA) > 10mm thick

6.2 A

In order to assess the rock stress factor *A,* estimates of intact rock strength and the maximum mining induced stress are required.

6.2.1 Intact rock strength

A comparison of the laboratory Unconfined Compressive Strength (*UCS*) test results with the field estimates of intact rock strength recorded on the borehole logs (*FES*) is shown in Figure 4.

The variability of the *UCS* tests and the difficulty of assigning a strength for each unit are clearly highlighted in this figure. The shale is also anisotropic, which tends to cause the *UCS* tests to fail along fabric rather than intact substance and result in a lower value. In light of this, the *FES* was selected as more representative of the intact rock strength.

6.2.2 Maximum induced stress

The maximum *in situ* stress is horizontal (σ_H) and approximately 2.5 times the vertical stress (σ_V) based on the testing carried out during the site investigations (see Section 5), i.e. $\sigma_H = 2.5\sigma_V$. It is estimated that the maximum mining induced stress will be approximately double that value, i.e. $\sigma_{max} = 2\sigma_H$.

Hence, a linear relationship of σ_{max} with depth is presented in Table 3.

The graph reproduced in Figure 5 shows the relationship between *A* and UCS / σ_{max}, i.e.

$$A = 0.1125\left(\frac{UCS}{\sigma_{max}}\right) - 0.125, minimum = 0.1\ and\ maximum = 1.0$$

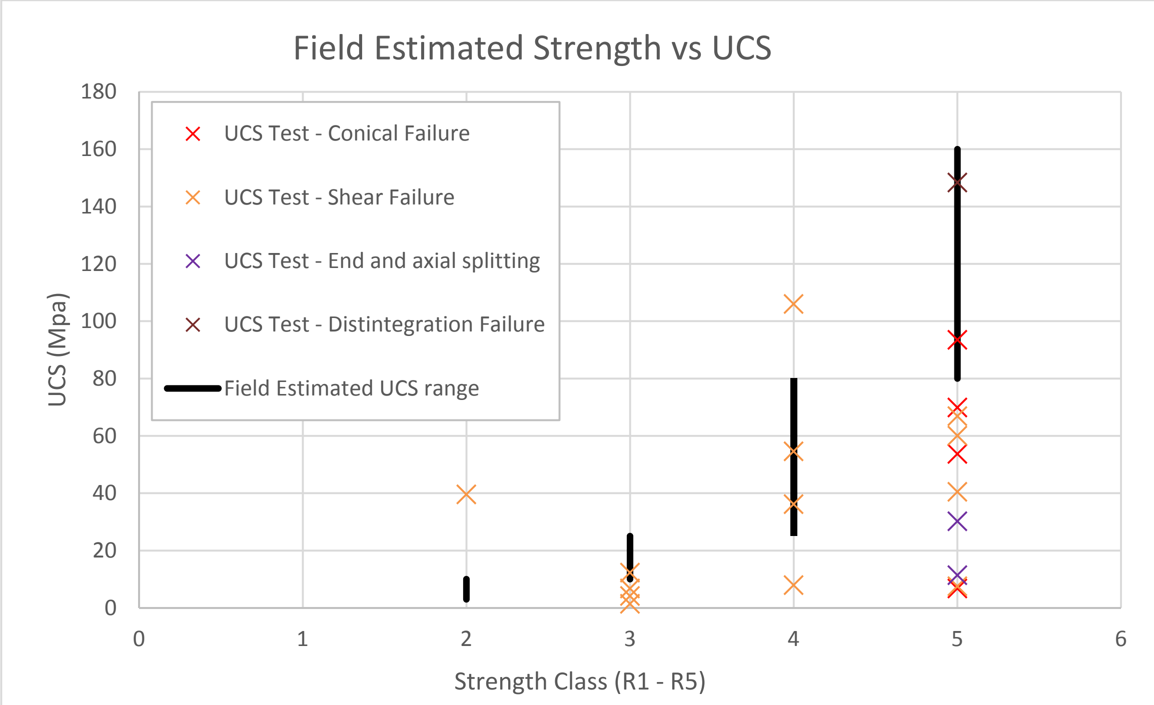


Figure 4: UCS vs Field Estimated Strength

TABLE 3
ESTIMATED MAXIMUM INDUCED STRESS AT CERTAIN DEPTHS

DEPTH (m)	σ_V (MPa)	σ_H (MPa) $= 2.5\sigma_v$	σ_{max} (MPa) $= 2\sigma_H$
50	1.9	4.8	9.6
100	2.8	7.0	14.0
200	5.6	14.0	28.0
300	8.4	21.0	42.0
400	11.2	28.0	56.0
500	14.0	35.0	70.0
600	16.8	42.0	84.0

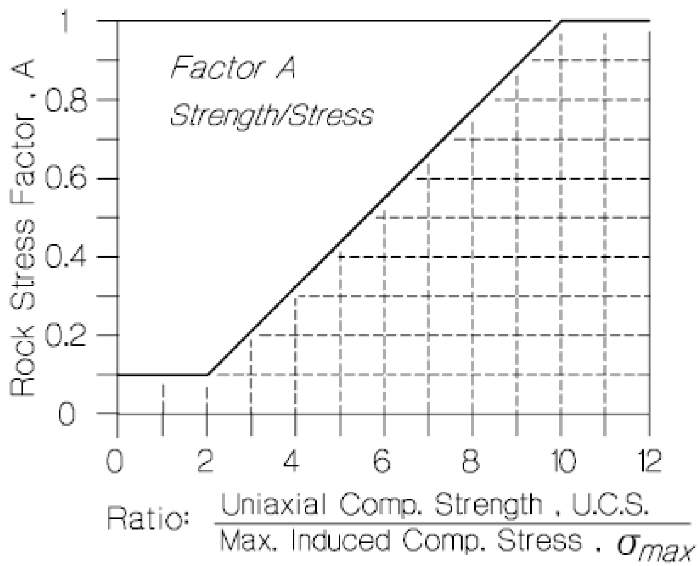


Figure 5: Graph to determine the A factor after Potvin, 1988

6.2.3 B

The joint orientation factor, *B*, was calculated following Figure 6.

- Stope parallel to ore strike — *B* = 1.0 for crown and 0.3 for backs
- Stope perpendicular to ore strike — *B* = 1.0 for crown and backs.

6.2.4 C

The gravity adjustment factor, *C*, factor was calculated following Figure 7.

- Stope parallel to ore strike — *C* = 6
- Stope perpendicular to ore strike — *C* = 8.

6.3 N'

The Modified Stability Number, *N'*, is calculated for each borehole and shown in the logs in Attachment A as:

- N' parallel to crown
- N' parallel backs
- N' perpendicular crown and backs.

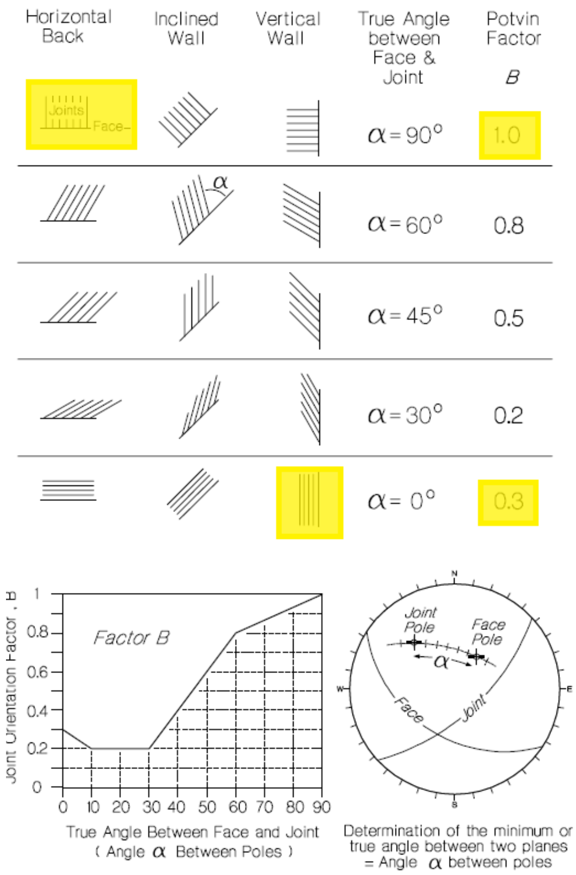


Figure 6: Determination of the B factor, after Potvin, 1988

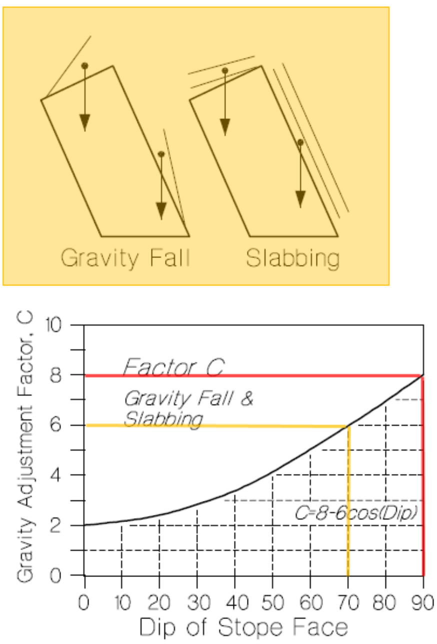


Figure 7: Determination of C factor (yellow line for parallel to ore and red for perpendicular), after Potvin, 1988

The distribution of all values for each rock mass unit is presented within Attachment B. The pertinent points are:

- The shale is a poorer quality rock mass at depths shallower than approximately 85 m:
  - Shale < 85m depth:
    - *Q'* and all *N'* values – Generally <10
  - Shale > 85m depth:
    - *Q'* - median of 27; range of 0.06 – 200
    - *N'* parallel to crown – median of 20
    - *N'* parallel to backs – median of 6
    - *N'* perpendicular crown and backs – median of 25
- Dolomite is generally a competent rock mass:
  - High *Q'* and *N'* values; generally >100
- Dolerite is a more variable rock mass:
  - *Q*' - median of 38; range of 0.06 – 400.

7 STOPE DESIGN

Stopes are assumed to be nominally 10 m wide and 30 m high based on the concept mining plan.

7.1 Stopes Parallel to the Ore Body

The hydraulic radius (HR), defined as the ratio of the stope face or wall area to its perimeter, is assessed for the backs and crowns of stopes parallel to the ore body. The stopes are wholly within shale.

Figures 8 and 9 present the range in the *N'* value with depth as a function of the HR for the shale ≥ 85 m depth and shale < 85 m depth, respectively. The figures show:

- The hanging wall HR is in the range of 3 to 6 for unsupported backs and up to 8 for cable supported backs
- The crown HR is in the range of 6 to 9 for unsupported crowns.

This equates to the following stope sizes:

- Unsupported stopes: 10 m wide x 30 m high x 25 m long
- Cable supported stopes:10 m wide x 30 m high x 40 m long.

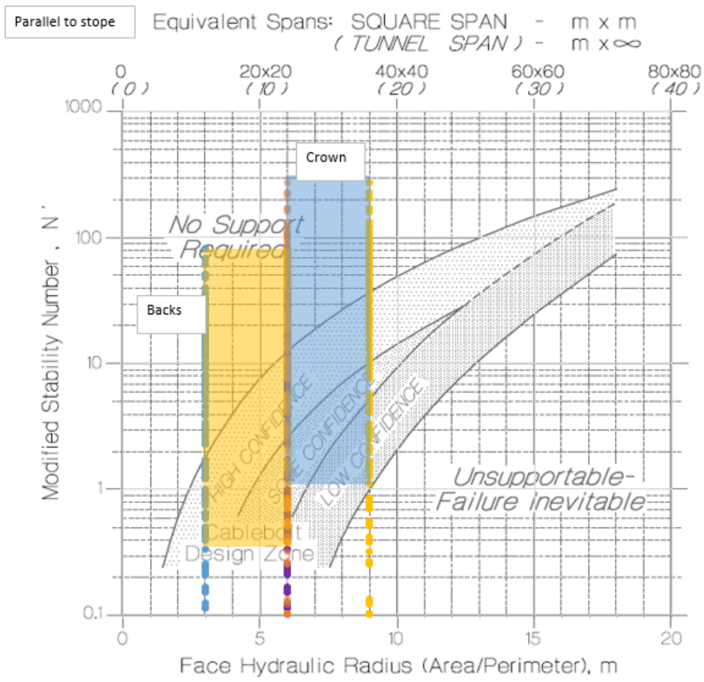


Figure 8: HR assessment for Shale ≥ 85 m deep (stopes parallel to ore body)

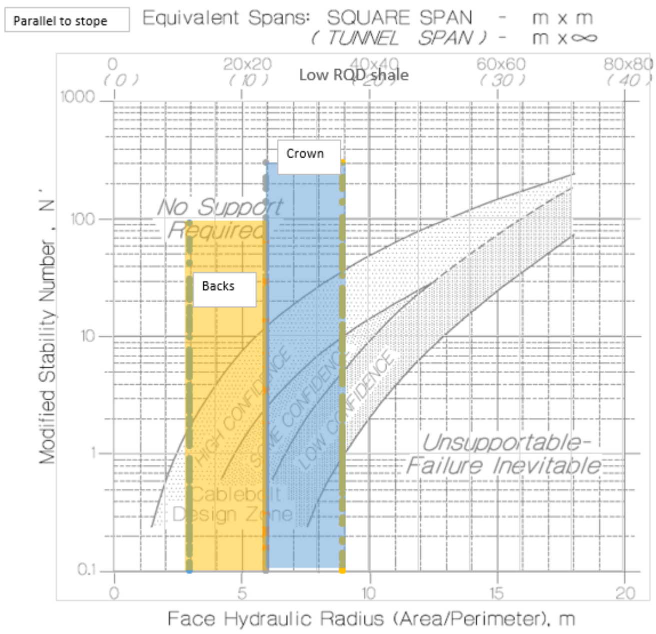


Figure 9: N' assessment for Shale < 85 m deep (stopes parallel to ore body)

7.2 Stopes perpendicular to the ore body

Similar to the previous figures, Figures 10 and 11 show the variability in HR for stopes perpendicular to the ore body within shale at ≥ 85 m depth and shale < 85 m depth, respectively. The HR ranges from 7 to 11 for unsupported stopes and up to 14 for cable supported stopes.

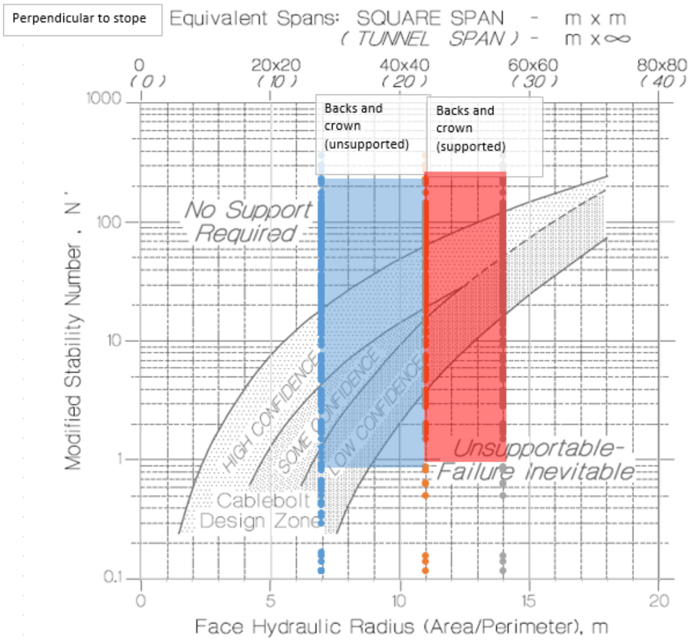


Figure 10: HR assessment for Shale ≥ 85m deep (stopes perpendicular to ore body)

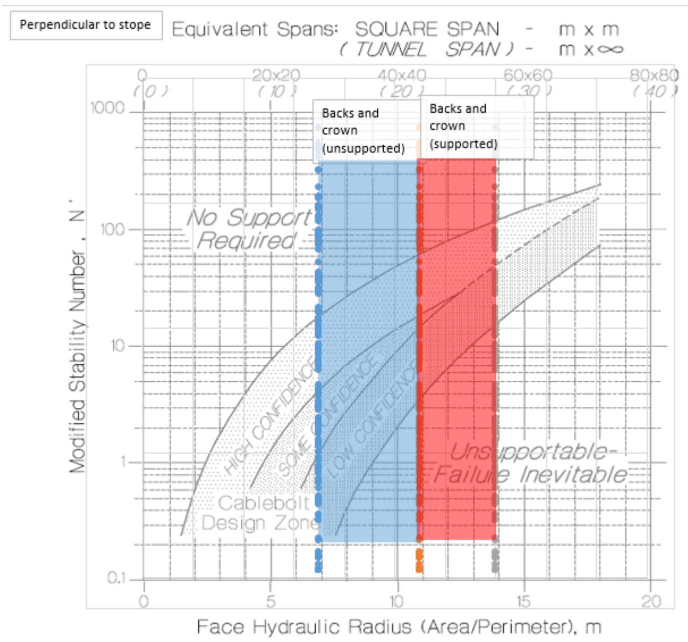


Figure 11: HR assessment for Shale < 85m deep (stopes perpendicular to ore body)

For shale at < 85 m depth, there is significantly higher scatter.   Stope sizes are:

- Unsupported – 10 m wide x 30 m high x 50 m long
- Supported – 10 m wide x 30 m high x 100 m long.

8 COMPARISON

The shale at Browns Underground is similar to the interbedded siltstone, carbonaceous mudstones at the Cosmo mine where PSM is providing geotechnical services.

The hydraulic radii used at Cosmo ranges are comparable to those estimated herein for stopes parallel to the ore body.

9 REFERENCES

1. Ahmad, M & Mudson, T.J. 2013. Geology and mineral resources of the Northern Territory. Northern Territory Geological Survey, special publication 5.
2. Barton, N., Lien, R. & Lunde, J. 1974. Engineering classification of rock masses for the design of tunnel support. Rock Mechanics. 6: 4: 189-236.
3. Potvin, 1988. Empirical open stope design in Canada. Ph.D. Thesis, Dept. Mining and Mineral Processing, University of British Columbia, 343 p.

For and on behalf of
PELLS SULLIVAN MEYNINK

JAMES SMITH
Engineering Geologist

ROBERT BERTUZZI
Principal

cc. John Wyche – AMDAD (john.wyche@amdad.com.au)

ATTACHMENT A

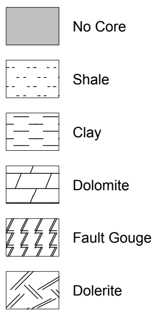
BOREHOLE LOGS WITH ASSIGNED Q' AND N' VALUES

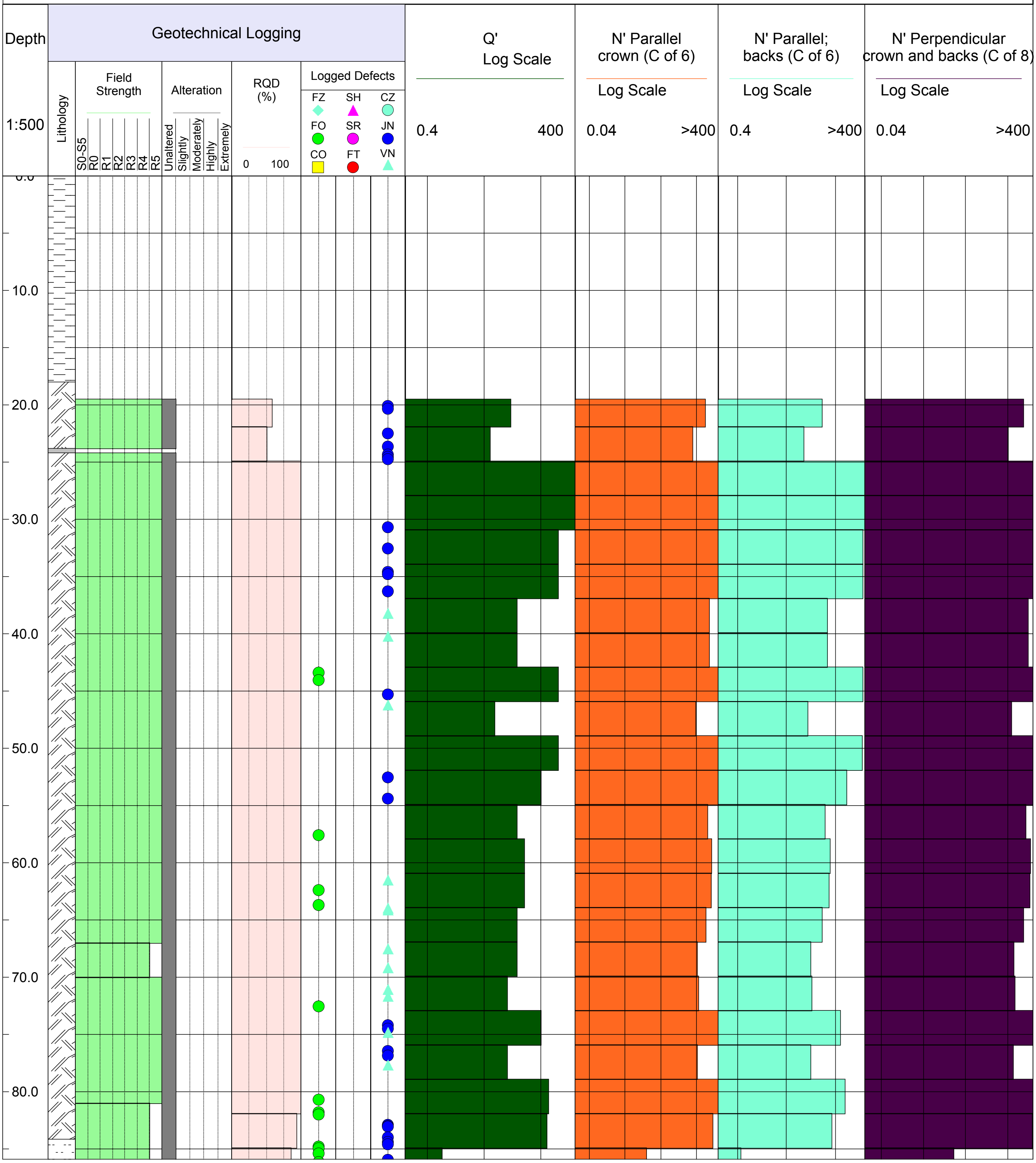
Browns Underground

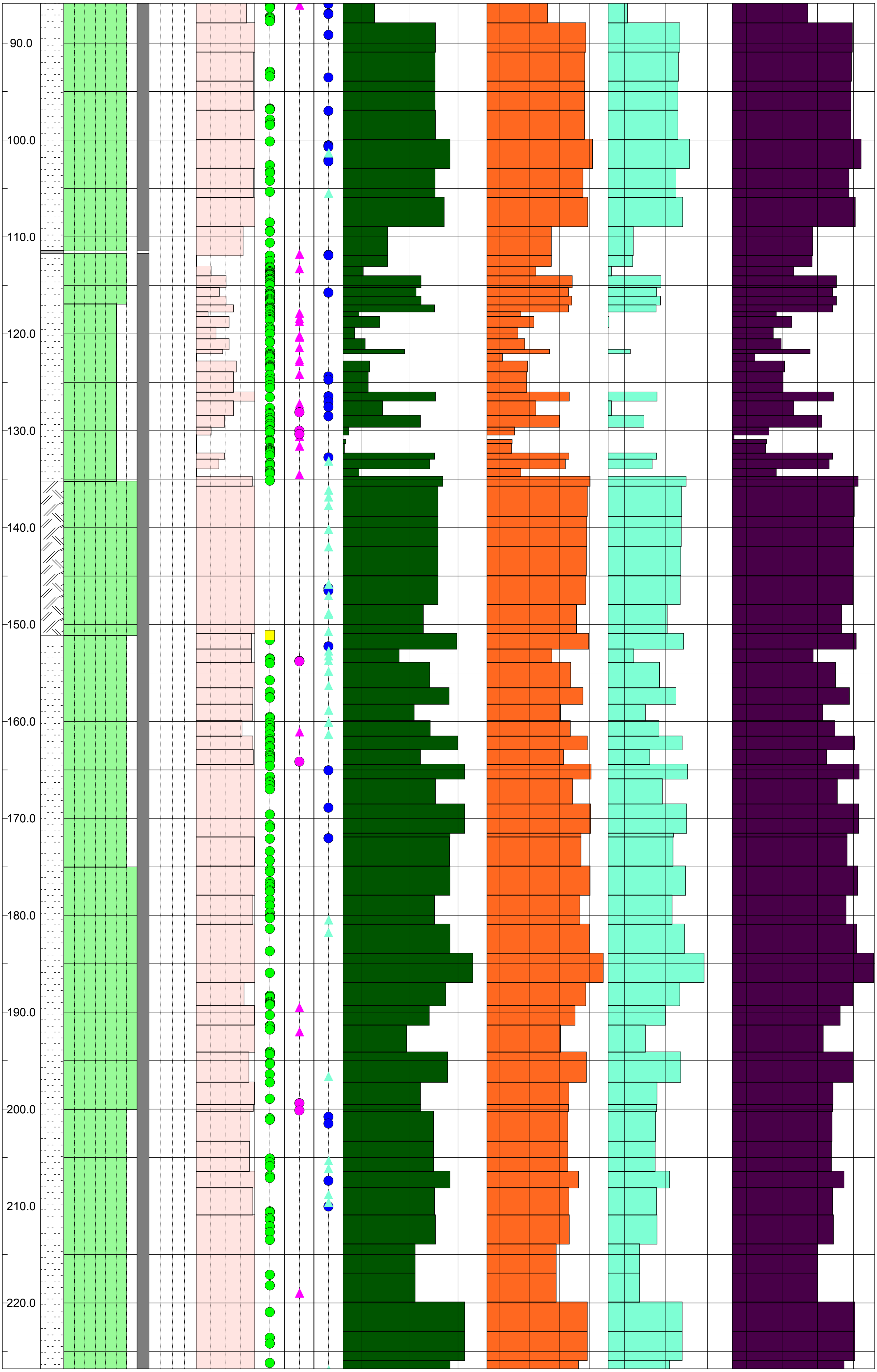
Hole I.D.	15BD01	Inclination	-77°
Client	HNC	Azimuth	333°
Location	716520 mE	Total Depth	388.0m
	8562700 mN	Commenced	22/09/2015
		Completed	7/10/2015

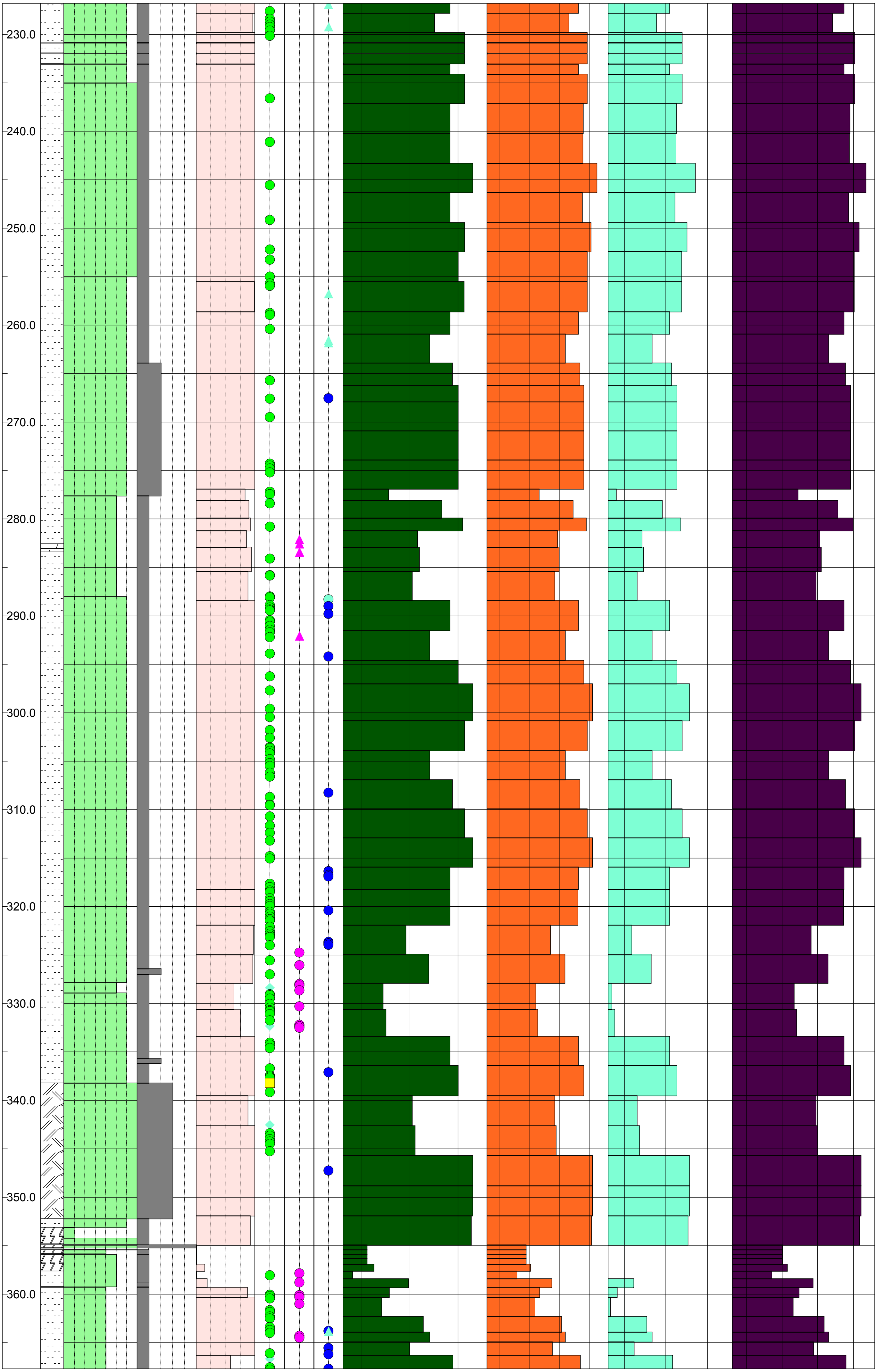
Driling Method	From (m)	To (m)
Percussion	0.00	18.0
HQ3	18.0	388.0

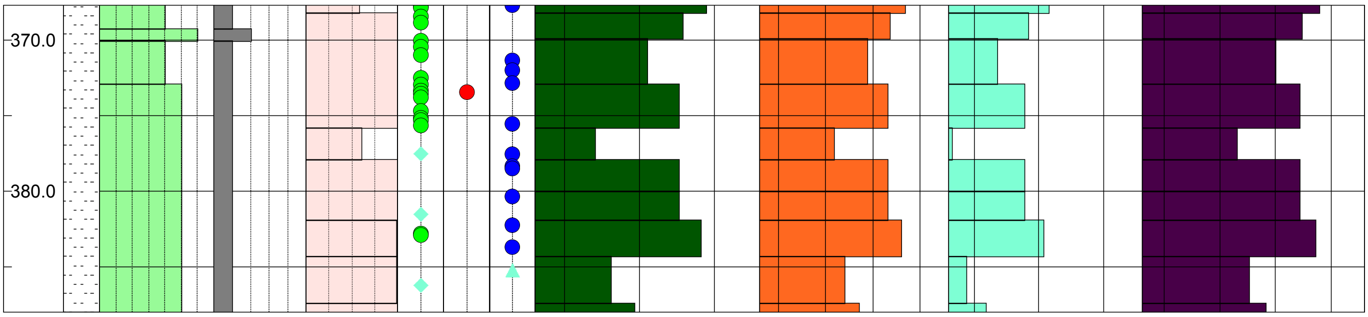
Lithological Key






90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0


230.0
240.0
250.0
260.0
270.0
280.0
290.0
300.0
310.0
320.0
330.0
340.0
350.0
360.0


370.0
380.0

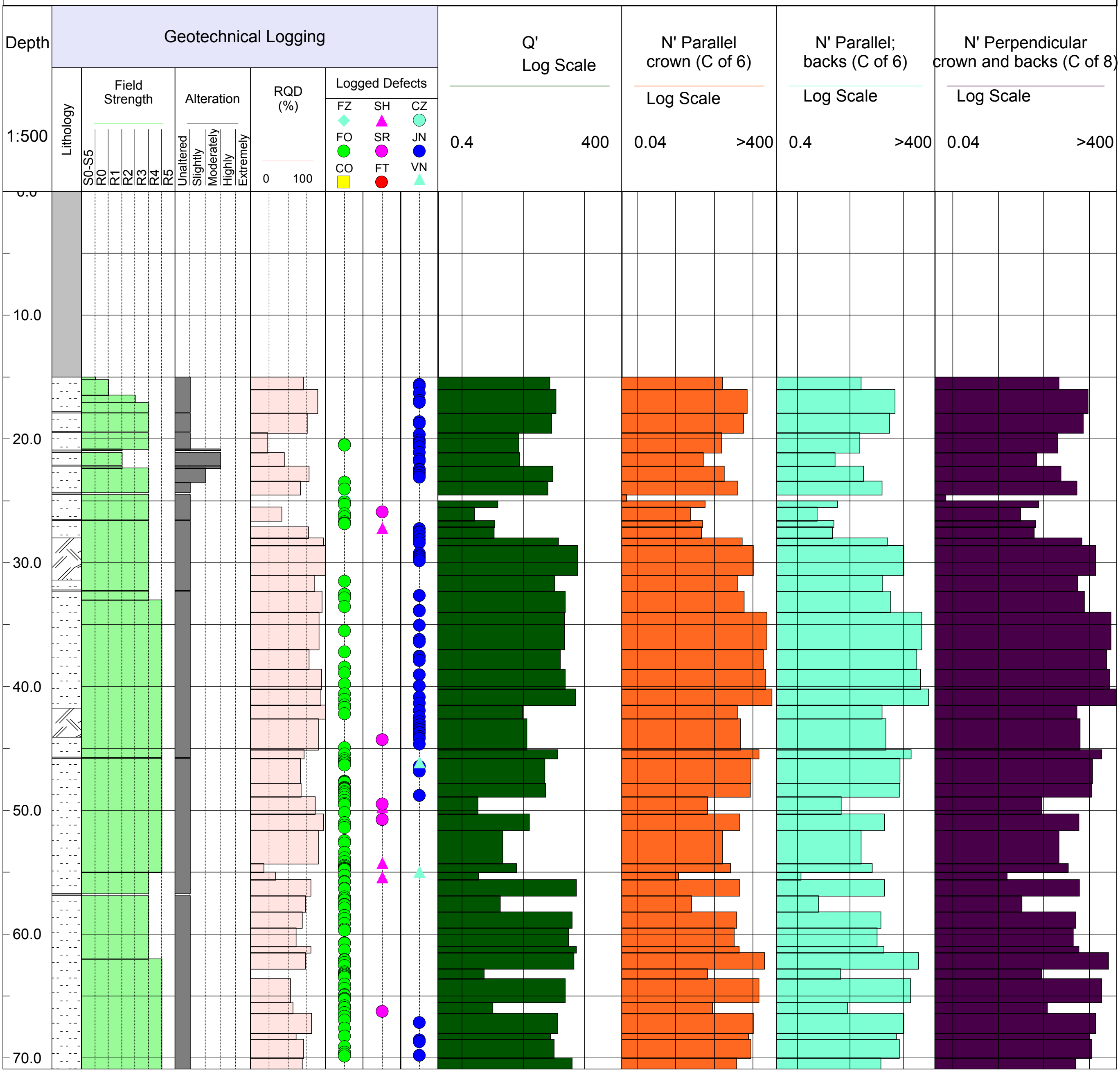
Browns Underground

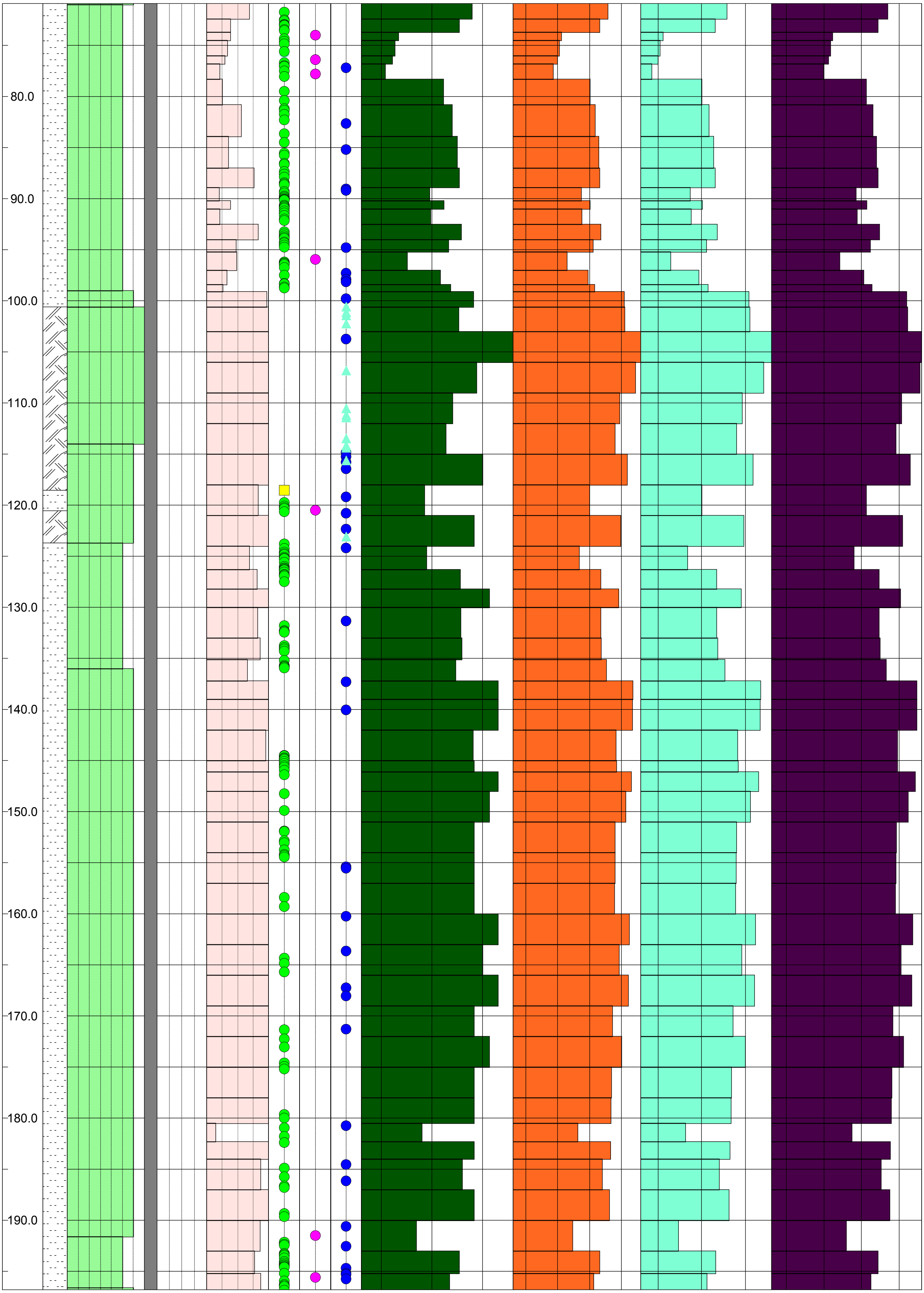
Hole I.D.	15BD02	Inclination	-76°
Client	HNC	Azimuth	104°
Location	716676 mE	Total Depth	220m
	8562850 mN	Commenced	13/10/2015
		Completed	19/10/2015

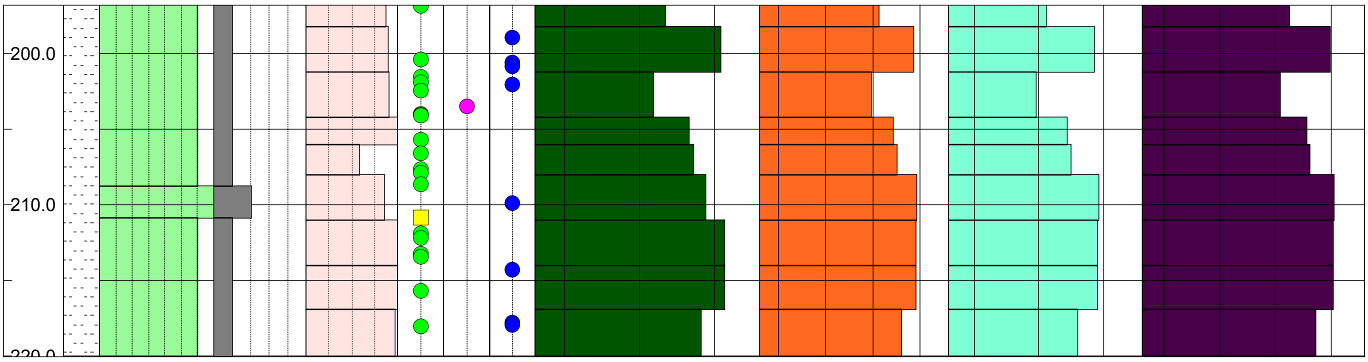
Lithological Key

- No Core
- Shale
- Dolerite

Driling Method	From (m)	To (m)
Pre-collared	0.00	15.0
HQ3	15.0	220




80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0


200.0
210.0

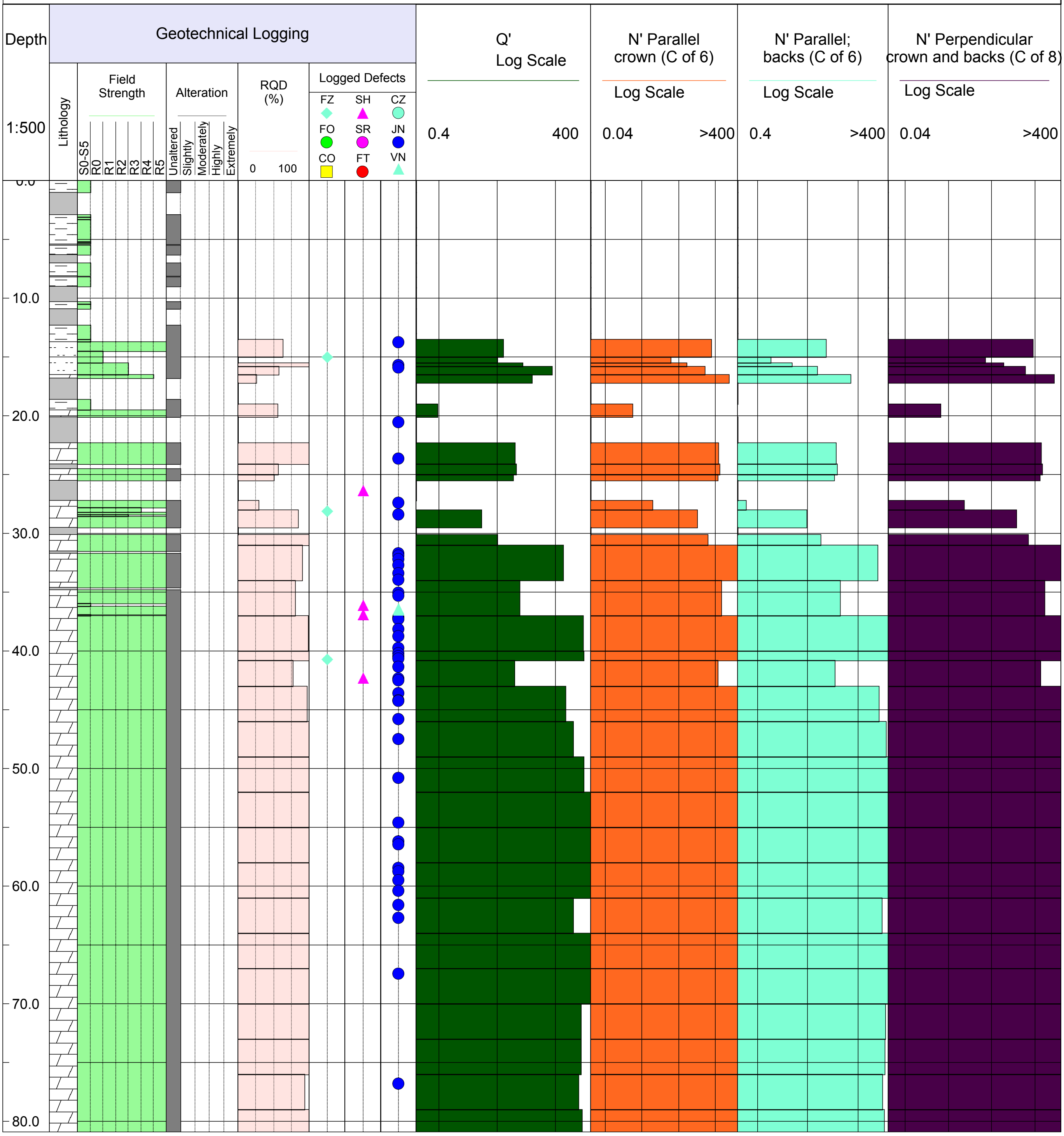
Browns Underground

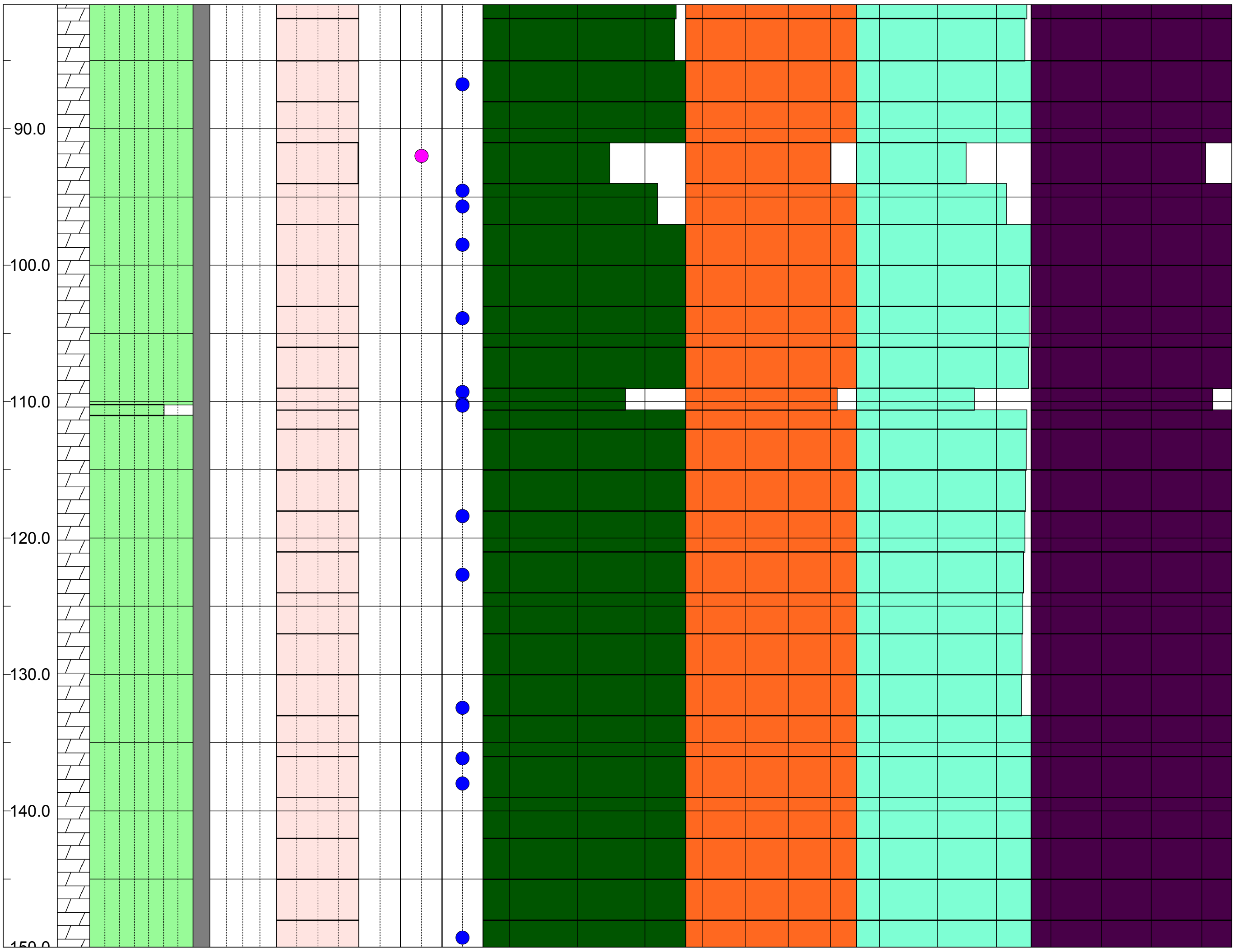
Hole I.D.	15BD03	Inclination	-70°
Client	HNC	Azimuth	180°
Location	716452 mE	Total Depth	150m
	8562936 mN	Commenced	7/10/2015
		Completed	12/10/2015

Drilling Method	From (m)	To (m)
HQ3	0.00	150

Lithological Key

- No Core
- Shale
- Clay
- Dolomite





90.0
100.0
110.0
120.0
130.0
140.0

Browns Underground

Hole I.D. 15BD04

Client HNC

Location 716375 mE

8562738 mN

Inclination -61°

Azimuth 229°

Total Depth 103.2m

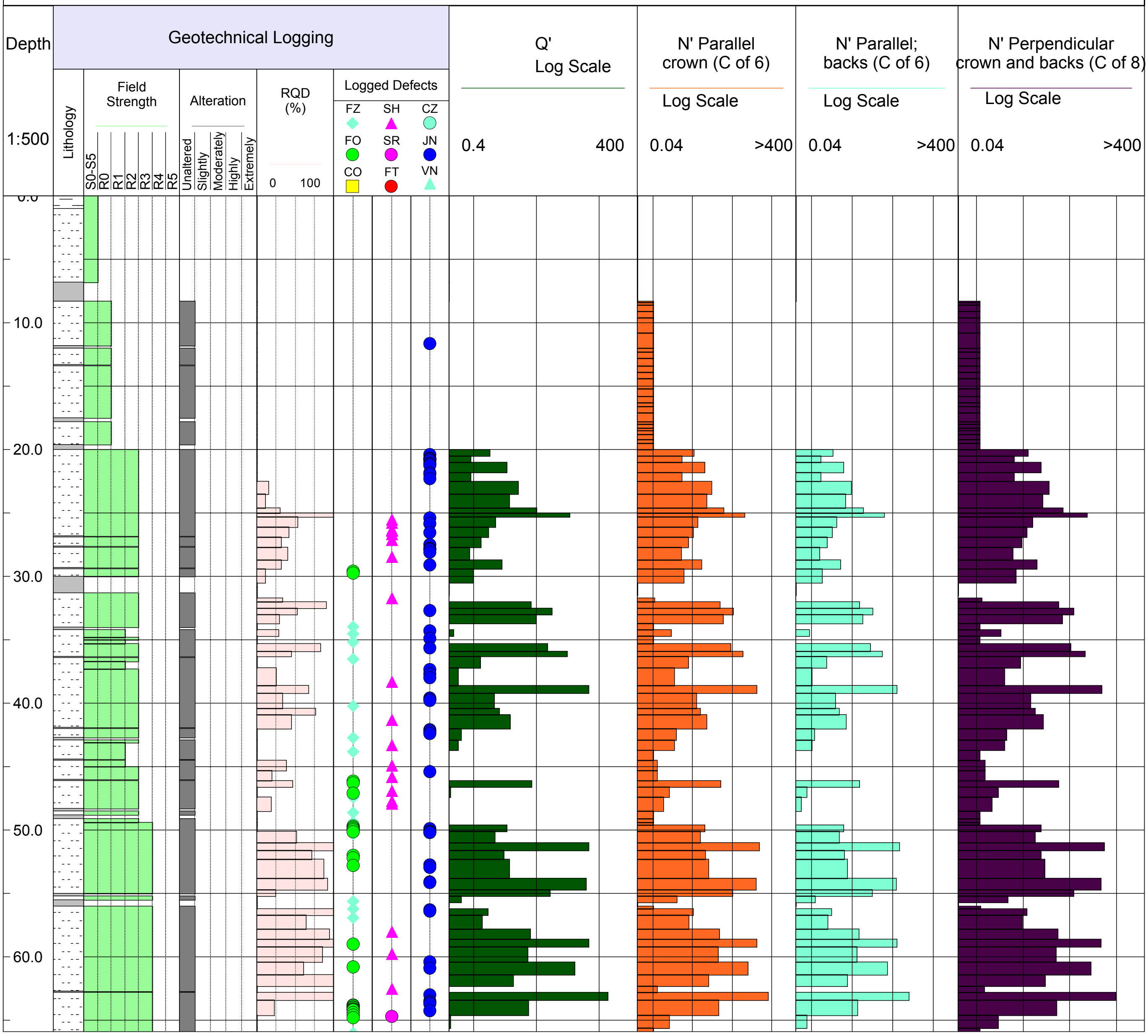
Commenced 23/09/2015

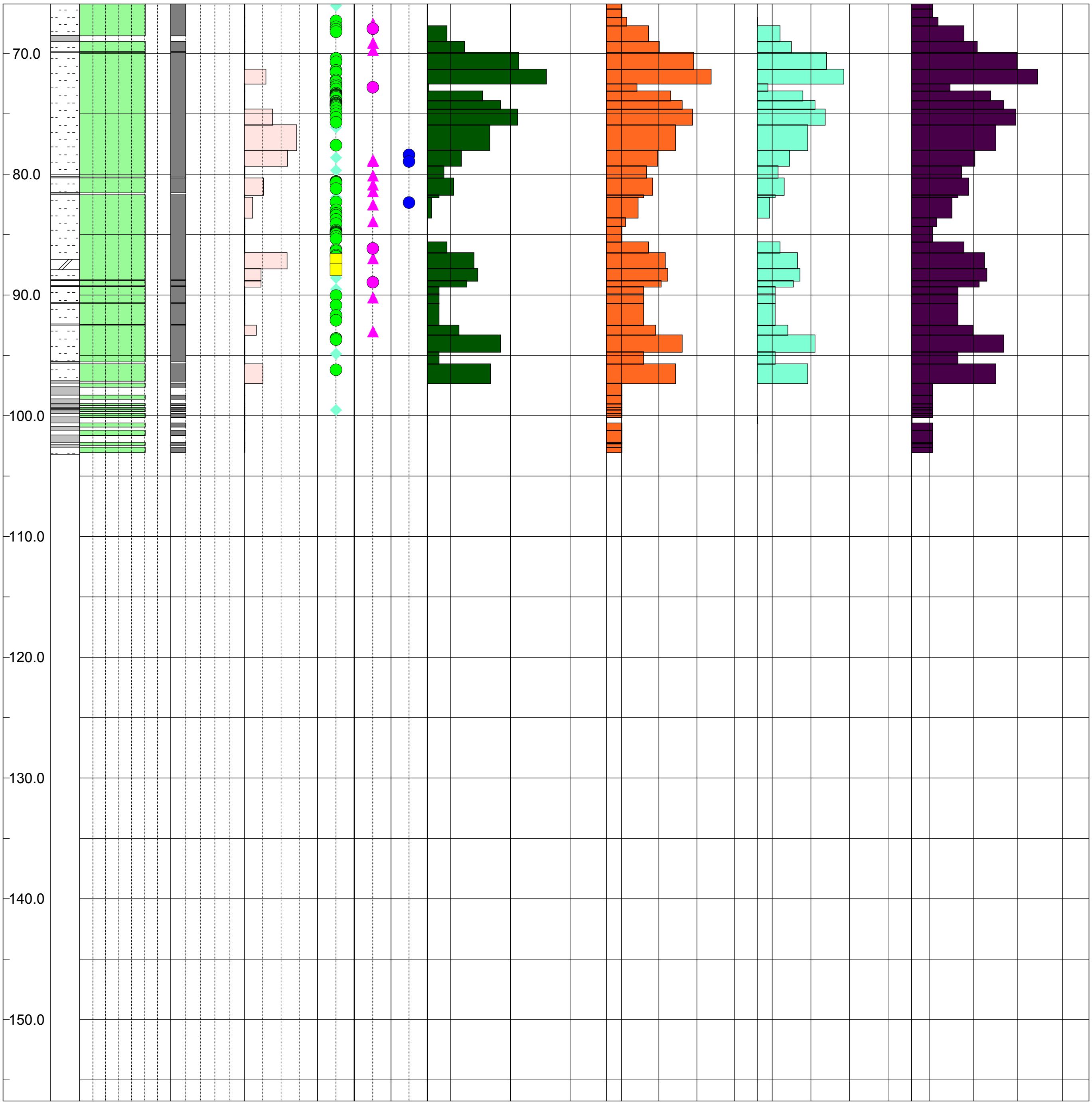
Completed 5/10/2015

Driling Method	From (m)	To (m)
Percussion	0.00	6.8
HQ3	6.8	103.2

Lithological Key

- No Core
- Shale
- Clay
- Dolerite




70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0

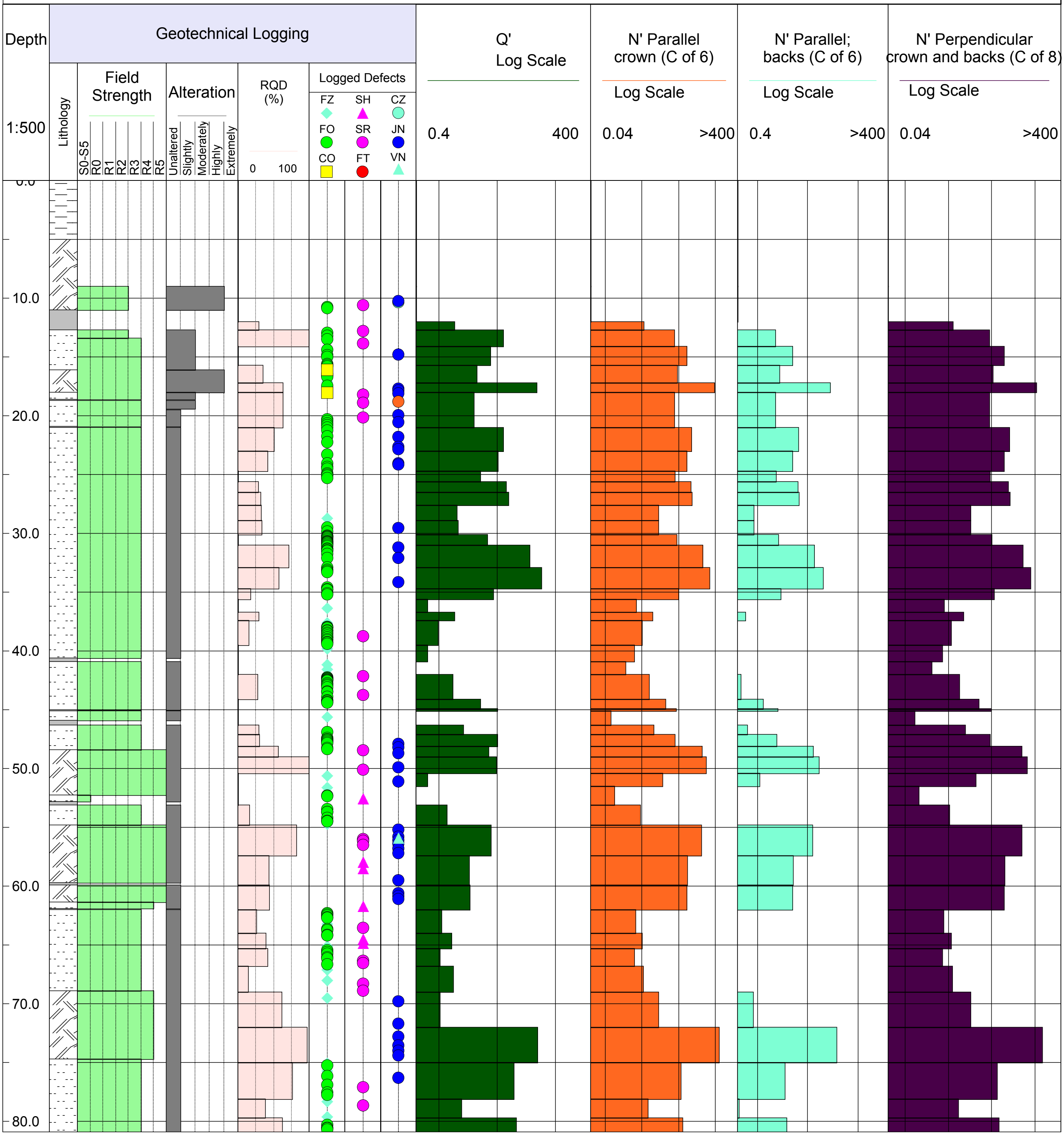
Browns Underground

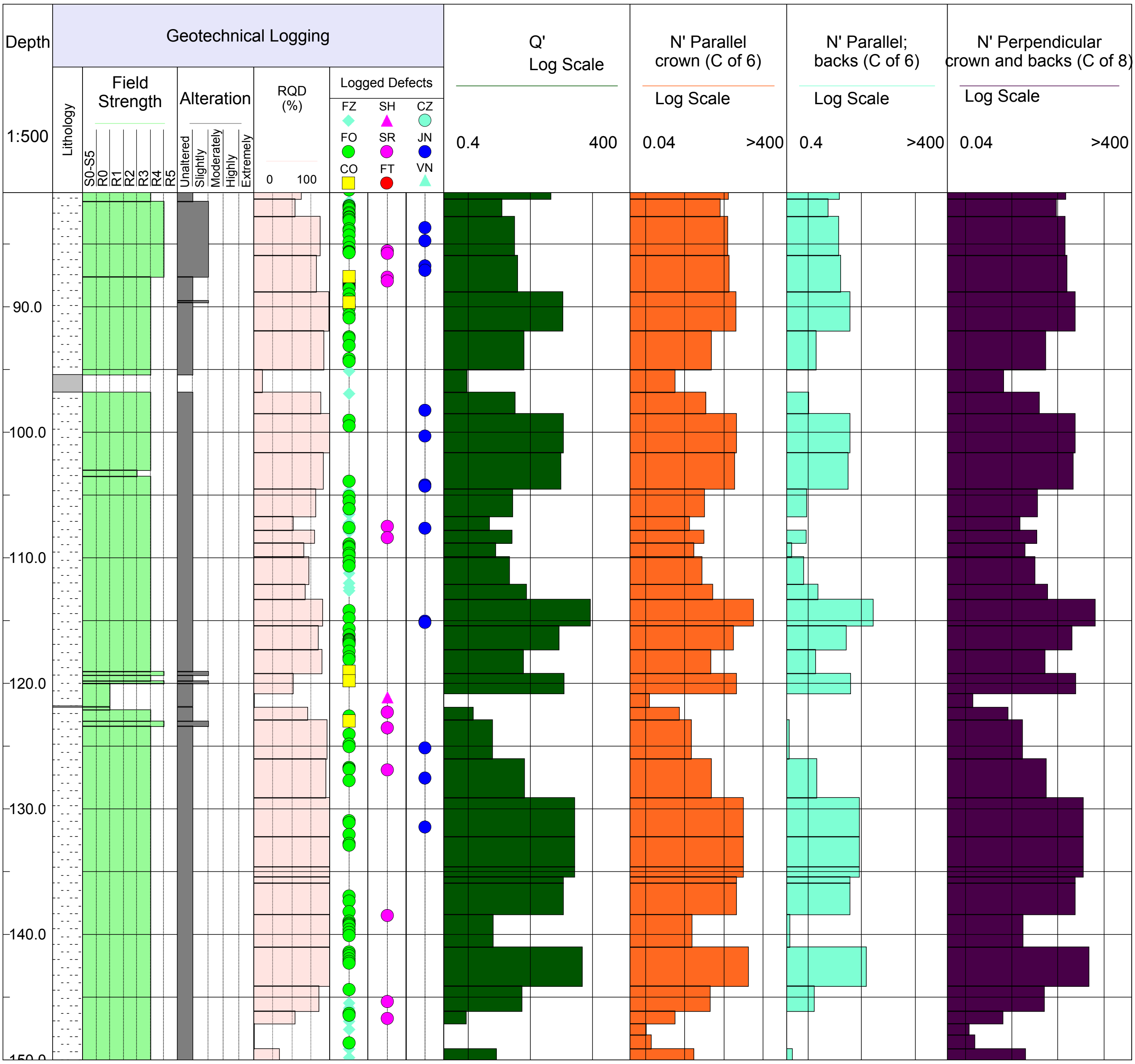
Hole I.D.	15BD05	Inclination	-59°
Client	HNC	Azimuth	330°
Location	716590 mE	Total Depth	150m
	8562780 mN	Commenced	22/09/2015
		Completed	12/10/2015

Lithological Key

- No Core
- Shale
- Clay
- Dolerite

Driling Method	From (m)	To (m)
Percussion	0.00	9.0
HQ3	9.0	150.0





Depth
1:500
Geotechnical Logging
Lithology
Field Strength
S0-S5
R0
R1
R2
R3
R4
R5
Alteration
Unaltered
Slightly
Moderately
Highly
Extremely
RQD (%)
0
100
Logged Defects
FZ
SH
CZ
FO
SR
JN
CO
FT
VN
Q' Log Scale
0.4
400
N' Parallel crown (C of 6)
Log Scale
0.04
>400
N' Parallel; backs (C of 6)
Log Scale
0.4
>400
N' Perpendicular crown and backs (C of 8)
Log Scale
0.04
>400
90.0
100.0
110.0
120.0
130.0
140.0
150.0

Browns Underground

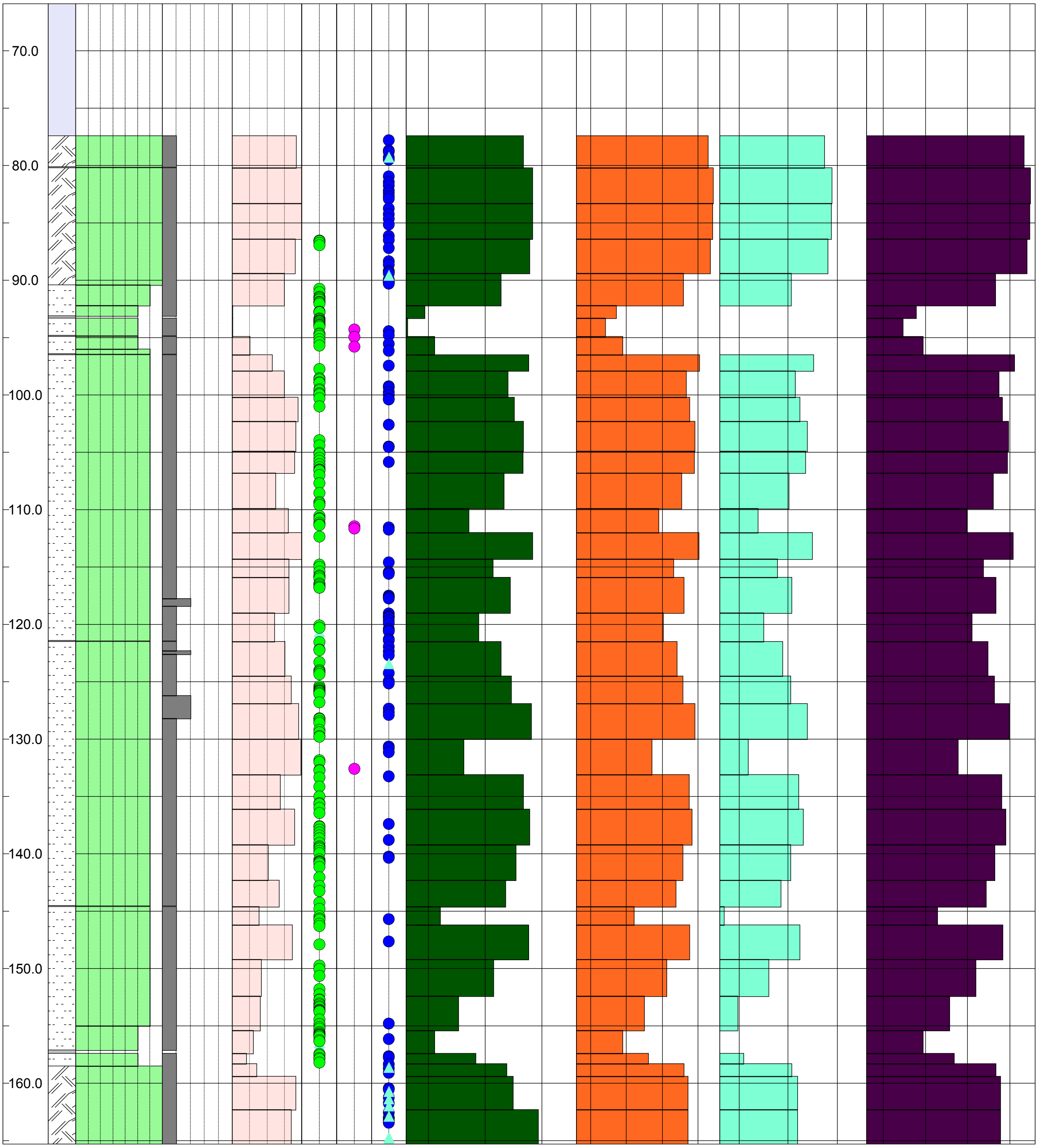
Hole I.D.	15BD06
Client	HNC
Location	716439 mE
	8562654 mN
Inclination	-59°
Azimuth	346°
Total Depth	165.3m
Commenced	13/10/2015
Completed	16/10/2015

Driling Method	From (m)	To (m)
Pre-collared	0.0	77.4
HQ3	77.4	165.3

Lithological Key

- Pre-collar
- No Core
- Shale
- Dolerite

Depth 1:500	Geotechnical Logging					Q' Log Scale	N' Parallel crown (C of 6) Log Scale	N' Parallel; backs (C of 6) Log Scale	N' Perpendicular crown and backs (C of 8) Log Scale
	Lithology	Field Strength (S0-S5, R0, R1, R2, R3, R4, R5)	Alteration (Unaltered, Slightly, Moderately, Highly, Extremely)	RQD (%) 0 100	Logged Defects (FZ, SH, CZ, FO, SR, JN, CO, FT, VN)	0.4 400	0.04 >400	0.4 >400	0.04 >400
0.0									
10.0									
20.0									
30.0									
40.0									
50.0									
60.0									



70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0

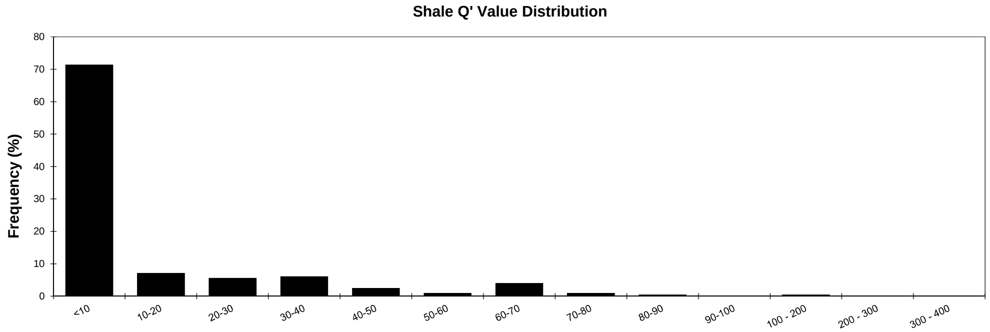
ATTACHMENT B

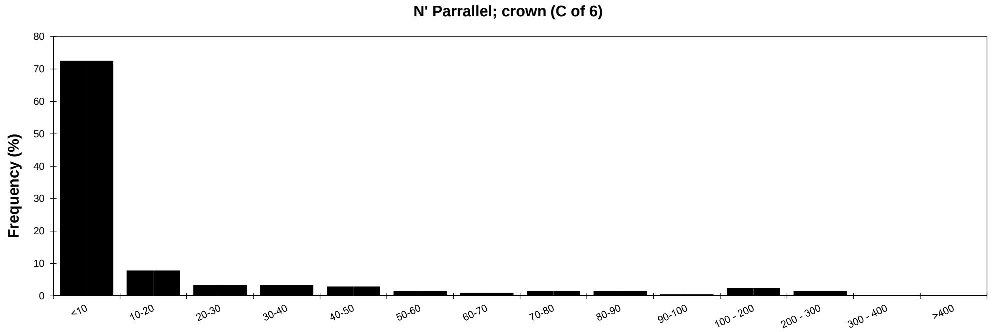
HISTOGRAMS OF Q' AND N' DISTRIBUTION BY ROCK MASS UNIT

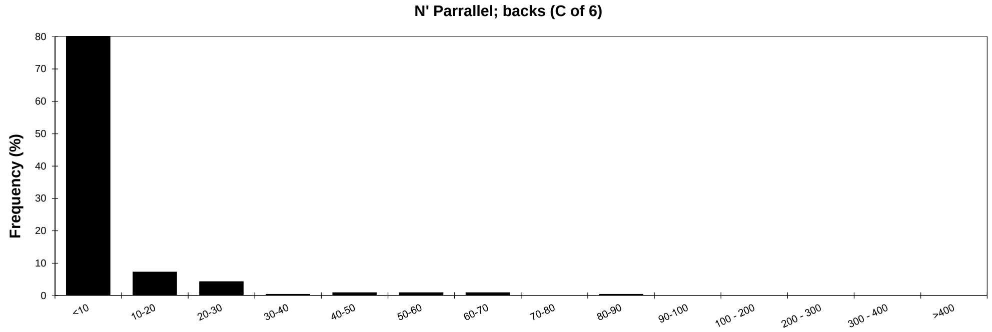
Pells Sullivan Meynink	Geotechnical Database
Engineering Consultants	Borehole Data Histograms
Rock - Soil - Water	

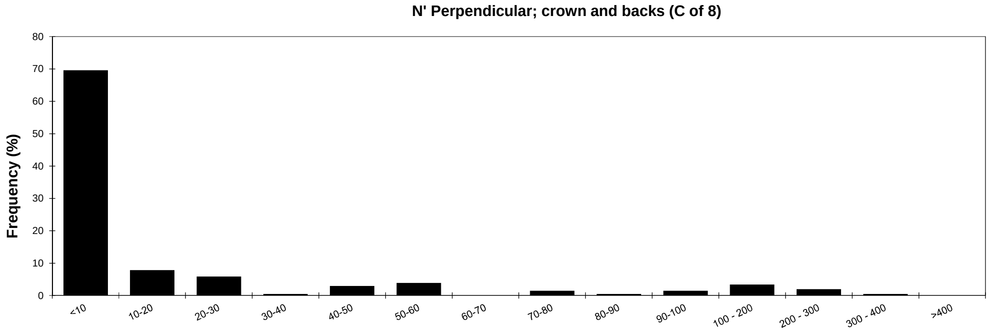
Job Number:	**PSM2584**	**Produced by:**	JS
Project:	**Browns Underground**	**Date**	1-Jun-16

Rock Mass Unit:	**Shale <85m Depth**	**Borehole:**	All boreholes
Lithology:	**Shale**		



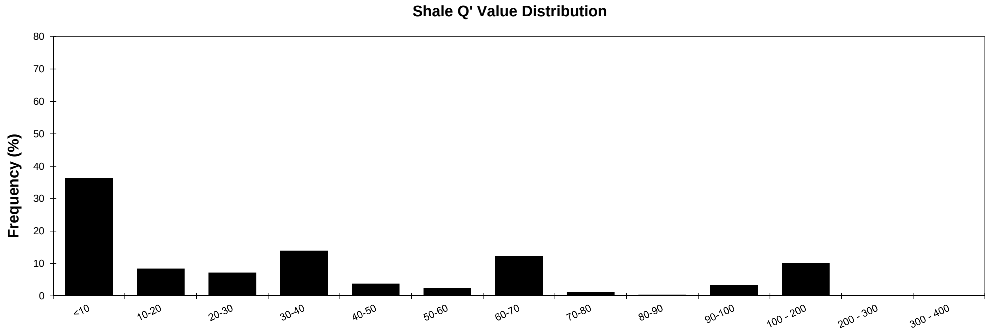


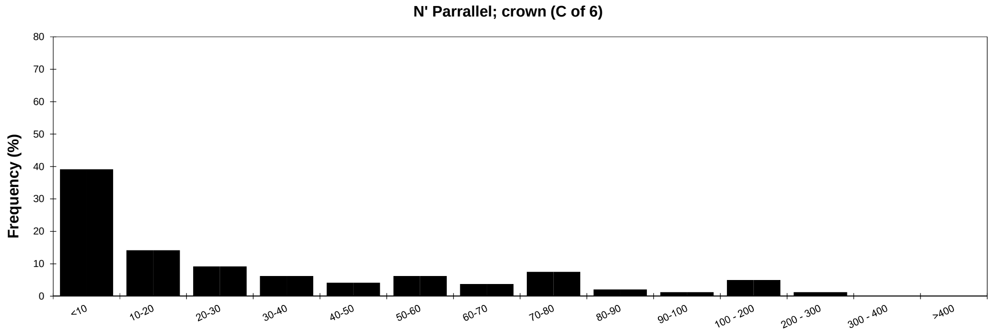


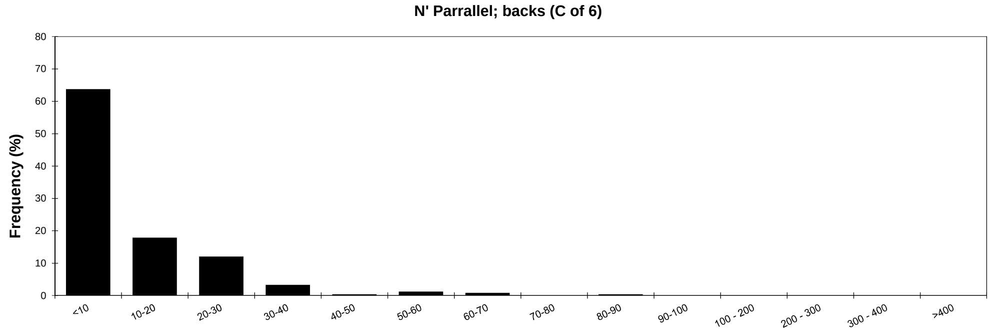


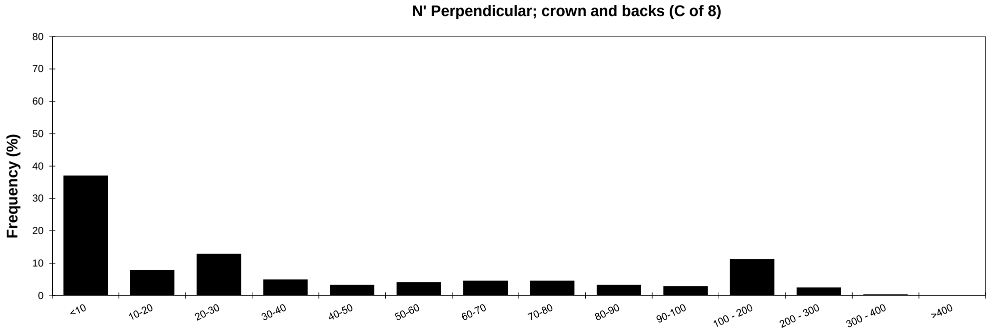
Job Number:	**PSM2584**	**Produced by:**	JS
Project:	**Browns Underground**	**Date**	1-Jun-16

Rock Mass Unit:	**Shale >85m depth**	**Borehole:**	All boreholes
Lithology:	**Shale**		









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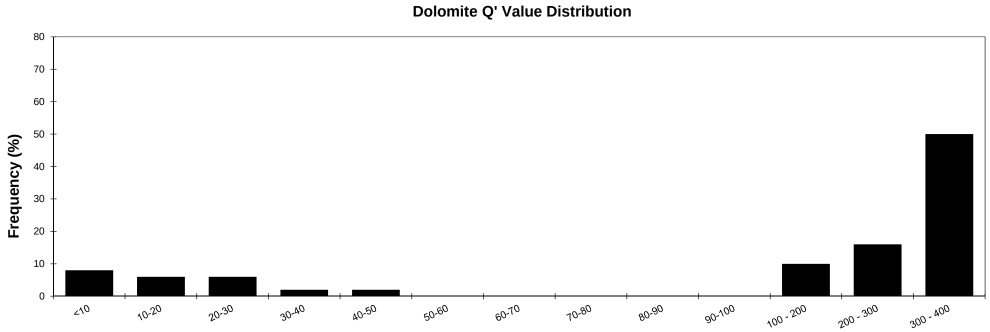
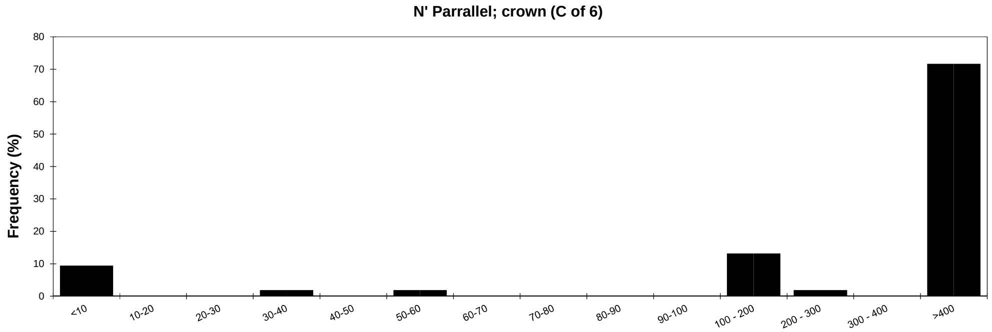
Rock - Soil - Water

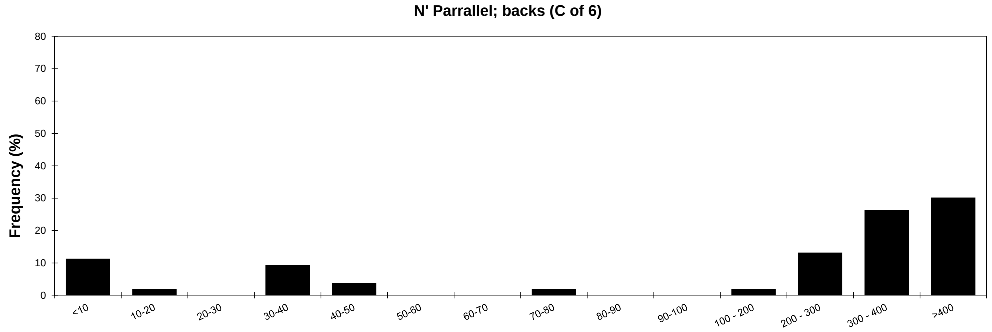
Geotechnical Database
Borehole Data Histograms

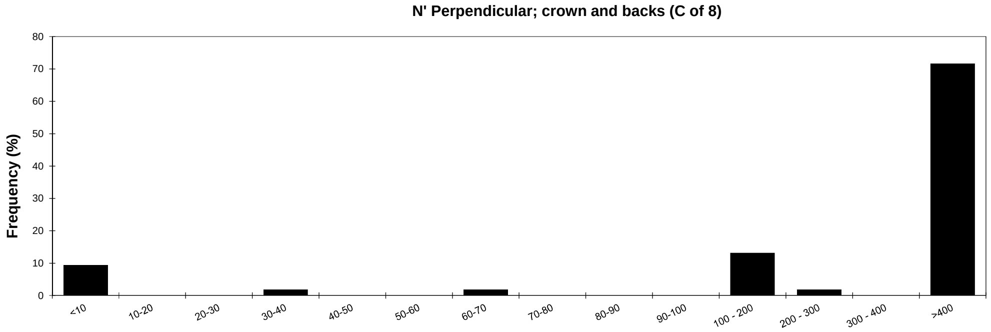
Job Number:	**PSM2584**	**Produced by:**	JS
Project:	**Browns Underground**	**Date**	1-Jun-16

Rock Mass Unit:	**Dolomite**	**Borehole:**	All boreholes
Lithology:	**Dolomite**		









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Geotechnical Database
Borehole Data Histograms

Job Number:	**PSM2584**	**Produced by:**	JS
Project:	**Browns Underground**	**Date**	1-Jun-16

Rock Mass Unit:	**Dolerite**	**Borehole:**	All boreholes
Lithology:	**Dolerite**