SSIM 2023 – PM Dight (ed.)

doi:10.36487/ACG_repo/2335_36

The value of senior-level practitioners logging core

C Morrell *WSP, Australia*

V Pere *formerly WSP, Australia*

Abstract

Geotechnical core logging is an important data collection activity in mining project studies as it establishes the foundation for geomechanical properties of the rock and design. However, this activity is often undertaken by junior personnel in their early career stages. A typical large feasibility study drill program may take six months to complete and could have four or more persons doing the logging. Quality assurance/quality control (QA/QC) is an important part of these programs to ensure consistency across multiple logging personnel, make sure scope targets are achieved and to deliver high-confidence datasets. The program outputs become more robust where that QA/QC is undertaken by highly experienced personnel. Having highly experienced senior-level practitioners heavily involved in the logging and QA/QC can add substantial value by driving efficiencies in the rock mass characterisation step of the geotechnical design process, thereby saving time and money during the modelling phase.

The value of a robust and timely QA/QC process was highlighted on Rio Tinto's Winu project where COVID-19 impacts resulted in a high turnover of core logging staff, with many being new to geotechnical core logging. Original proposals for senior-level QA/QC coverage were no longer adequate to achieve scope, and limited personnel availability resulted in sustained senior-level support onsite for much of the project.

QA/QC was completed onsite as soon as initial logging was completed, from the two operating drill rigs, which gave constant feedback on achieving scope targets. Golder Associates, now WSP, was able to guide material laboratory testing programs more intimately and also initiate material characterisation early in the drill program. This early access to high-confidence QA/QC-checked data enabled revisions to the drillhole program and geotechnical targets to be made almost instantly.

Typically, the level of QA/QC coverage provided by WSP would not be well supported considering the significant number of senior-level hours involved. However, the intangible benefits of this approach were realised as fewer client queries on geotechnical properties were derived from the logging data. In addition, the high confidence in the modelling outputs meant that fewer sensitivities were required, saving time and money during the modelling phase.

Keywords: *geotechnical, core logging, COVID-19*

1 Introduction

This case study presents the work undertaken to support material characterisation at the Rio Tinto Copper Winu site, located in the Great Sandy Desert in the Pilbara region of Western Australia (WA). Geotechnical studies were undertaken on the developing project for Rio Tinto Copper from 2020 to 2022. Field programs were undertaken in 2020 and 2021, through the height of COVID-19 restrictions. More than 10 km of core was drilled and logged from 30 boreholes utilising 16 different core loggers to manage the two rigs assigned to the drilling. The expertise of the core loggers ranged from low to very high, and there was significant potential for variability in the way that the core data was interpreted and ultimately captured.

This case study discusses the original scope and presents the revised strategy that was required to deliver confident data from the geotechnical field program. This study will show the value in using senior-level rock mechanics engineers to undertake comprehensive quality assurance/quality control (QA/QC) on geotechnical cores to create an extremely robust and defensible dataset, creating time and cost savings for the client.

2 Pre-COVID-19 proposed geotechnical investigation program

2.1 Scope

The original scope of work for the geotechnical logging field program proposed to use three geotechnical loggers covering two drill rigs on a rolling two-week-on, one-week-off roster. Ideally, geotechnical loggers with one to two years' experience would have been desirable for the project. However, due to a lack of available staff in Perth, junior geotechnical loggers with little to no field or logging experience were brought in from Golder offices in New Zealand and Brisbane to support the field program. QA/QC was planned to be completed over a few weeks using a floating roster that overlapped logger change days. It was thought that the amount of time spent onsite by senior staff completing QA/QC would decrease over the course of the field programs as the loggers gained experience and alignment.

Training would be important during the initial stages to make sure all loggers were aligned as they had limited experience in geotechnical logging in WA's geology. Training and logging were undertaken under the guidance of a principal rock mechanics engineer and a senior rock mechanics engineer.

Sampling, in-field tests, and the installation of vibrating wire piezometers were also part of the field program and were to be managed by the rock mechanics engineers undertaking the logging; again with support and oversight from senior personnel.

2.2 Core logging

Geotechnical core logging captured the intact rock and discontinuity properties from recovered drill cores (Figure 1). Logging was completed at the rig as possible to allow direct review of the core during recovery and for timely sample capture. This was especially important when collecting mudstone samples, to allow testing at its most intact state and with in situ moisture content.

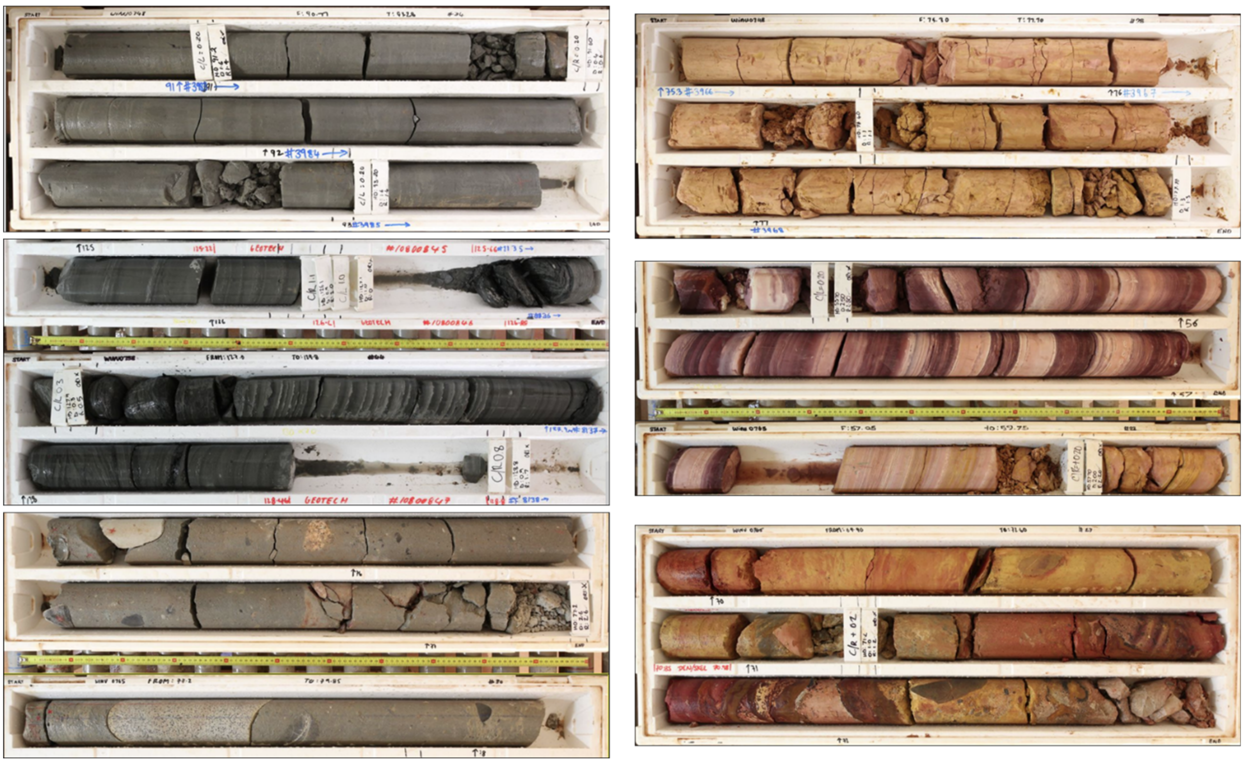

Figure 1 Mudstone was one of the more difficult materials to log due to the significant variability in how it presented

Data was recorded digitally in the field to capture both interval and point details (Table 1). The logging database was set up specifically for the Winu project rock to enable high-confidence data capture for the geotechnical characterisation of the local material.

Table 1 Geotechnical fields captured by loggers

Type	Geotechnical field
Domain interval	Depth as from and to Aggregate measure of samples longer than or equal to 10 cm for rock quality designation (RQD) Longest piece measured Field estimated strength using International Society for Rock Mechanics strength classes Microdefect intensity and strength Open joint count Alternation Weathering Dominant interval character (e.g. soil, intact rock, lost core) Lithology
Soil	Depth as from and to Presence of organics Principal soil material and abundance Secondary soil material and abundance Tertiary soil material and abundance Soil grading Colour Grain shape Moisture content Cohesiveness Soil class based on the Unified Soil Classification Scheme
Point detail	Depth, where from equals to Open or closed Alpha and beta Discontinuity type Discontinuity termination Infill thickness Joint roughness (Jr) Joint alternation (Ja) Joint condition (JCR89)

2.3 Quality assurance/quality control

All logged holes were to be reviewed and quality checked in the field by a senior rock mechanics engineer, with additional assurance to be provided by a principal rock mechanics engineer.

The QA/QC process reviewed the data for completeness and made checks on the alignment across all loggers. These checks included:

- Geotechnical interval selection.
- RQD measurements, longest piece and joint count.
- Field estimated strength.
- Weathering and alteration.
- Microdefect intensity and strength.
- Joint roughness and joint alternation.
- Joint condition rating.
- Quantity and quality of samples.
- Soil properties.

Any changes to the core logs were communicated to Rio Tinto for uploading into their geological database so further data quality and integrity checks could be undertaken. The finalised logs were then released to the consultant for further use and ensured that Rio Tinto had a controlled dataset and clarity on the quality of the data being used by the consultant for the characterisation and design work.

2.4 Characterisation and design

The quality-checked dataset was then to be used to support material characterisation works in the consultants' Perth office. This would then segue through stability analysis and the design phases.

3 COVID-19 impacts

Travel restrictions initiated in 2020 by the WA Government during the COVID-19 pandemic saw major changes to how travel across Australia and within the state of WA occurred. These restrictions continued to impact work through the 2021 field program with site shutdowns, lockdowns in Perth and a reduction to one rig allocated to the program.

WA state border closures in 2020 meant that loggers from the New Zealand and Brisbane offices were unable to continue on the project. The consultant utilised hydrogeologists who were familiar with the project and civil geotechnical engineers to complete the geotechnical logging. Rosters onsite were revised to a two-panel system which required personnel to be onsite for the full duration of a 15-days-on and 13-days-off roster. To support the training and QA/QC work required, a senior-level rock mechanics engineer was onsite full-time.

Further changes to the program occurred in 2021 when a second drill rig was allocated to the program and additional core loggers were required. This was during a period where personnel were extremely difficult to source in WA. Rio Tinto personnel were transitioned into the logging roles to support the additional logging requirements. Senior-level rock mechanics engineers were used to cover gaps in the logging roster due to travel restrictions within WA and the fact that access to the site could be done on weekly rotations.

The senior rock mechanics engineers were back-to-back onsite, undertaking QA/QC, training and core logging for most of 2021. Fortunately there was time at the beginning of the 2020 field program where both were onsite and alignment discussions were able to be held. The alignment between these key personnel was reinforced with regular contact and discussions.

These unavoidable changes increased cost to the field program from the significant additional hours needed to meet travel and roster requirements. However, this circumstance enabled more senior-level personnel to take more direct control of the program and ensure robust QA/QC, which ultimately led to longer-term benefits.

4 Benefits of senior practitioners in-field

4.1 Immediate feedback to the drilling program

With QA/QC being completed onsite as soon as initial logging was completed, immediate feedback was provided and helped retain focus on achieving scope targets. Rock mechanics engineers were able to guide material laboratory testing programs more intimately and also initiate material characterisation much earlier in the drill program. It was this immediacy of the feedback and direct validation from a characterisation perspective that improved confidence in the dataset.

Geotechnical targets were able to be checked and revisions made to drillhole plans during the field program. Some boreholes were able to be shortened where all necessary data was recovered, and the surplus metres applied to other holes or drilling targets. Similarly, if more samples of a certain material were needed, a hole could be extended to capture them. The ability to respond to identified conditions would not have been as easy if there was not constant feedback from the logged holes by senior personnel.

Greater emphasis could also be placed on achieving quality geophysical targets and any decisions needed to balance drill program progression against the importance, or timing, of obtaining required data could be made immediately in the field.

4.2 Sample selection

Samples were regularly shipped from site during the field program and laboratory testing requests were often made before the core had left site. The rapid turnaround gave access to preliminary material characteristics and helped guide future laboratory testing. Time and cost savings were achieved as the office-based rock mechanics engineers could start to develop unit summaries and material characterisation parameters while the field program was underway.

This in turn identified gaps in the data and opportunities to subdomain early enough in the program that revisions could be made to modify the drill program or get additional samples before drilling was completed.

4.3 High-confidence dataset

A significant return from the additional time invested in senior personnel in the field was the consistent, reliable and high-confidence core logging dataset delivered as a result of the rigorous QA/QC (Table 2). This provided outputs that were easily communicable to both the client and external reviewers, and which were carried through the material characterisation and stability analyses.

High-confidence bounds on the dataset also made any required sensitivities more readily apparent. This translated to greater support of the outputs generated from the modelling. There was never a need to return to the dataset to see if revisions could be made to refine results.

The high-confidence dataset aligned with the risk-based decision-making approach adopted by Rio Tinto as it clearly communicated the reliability of the geotechnical work undertaken and associated risks to the proposed design.

Further benefits were realised from the reduced time required during the material characterisation stage, where interpretations and decisions that had already been made and tested in the field were used to rapidly progress domaining and determination of strength properties to be used in the analyses. This offset some of the additional time spent in the field. Deadlines could also be tighter as work was being done concurrently and key personnel were already deeply engaged.

Table 2 Scale of change

Degree of confidence	Level of QA/QC undertaken
Low	No QA/QC
Moderate	QA/QC performed after logging program or from core photographs
High	Experienced personnel intimately involved at all stages with overarching QA/QC as well

4.4 Personnel development

Often core logging is undertaken by personnel early in their career and they are not always well supported through ongoing QA/QC or in a position to work alongside, and be mentored by, highly experienced geotechnical practitioners.

Twelve of the sixteen, or 75% of, the core loggers had limited to no core logging experience, but by the end of the program all of them had received one-on-one training and support for the duration of their time onsite. The skills that they were able to develop, the incidental conversations around what goes into a geotechnical program and discussions on why activities are being done in a certain way, provided all of these team members with valuable experience that is not always accessible to developing practitioners.

5 Conclusion

COVID-19 impacts resulted in high turnover of core logging staff during the 2020 and 2021 field programs, with many being new to geotechnical core logging. Original proposals for senior-level QA/QC coverage were no longer adequate to achieve scope and the limited personnel availability resulted in sustained senior-level support onsite for much of the project. This greater emphasis on QA/QC for the alignment of logging created an extremely robust and defensible dataset that would not have been achieved otherwise. The resulting rock mass units that were developed had been revised throughout the different iterations of reporting as new milestones in the field programs were achieved, and are considered to be extremely robust and well tested.

This early access to high-confidence QA/QC-checked data enabled revisions to the drillhole program and geotechnical targets to be made almost instantly.

Typically, the level of QA/QC coverage provided by the consultant would not be well supported by the client or consultant, considering the significant hours of senior-level hours involved. However, the intangible benefits of this approach were realised as there were fewer client queries on the geotechnical properties derived from the logging data, and the high confidence in the modelling outputs meant that fewer sensitivities were required, saving both time and money during the modelling phase.

This approach would not be suited to all geotechnical field programs, however, large-scale projects such as Winu – which had little to no quality geotechnical data available – would benefit greatly from having a larger presence of senior-level staff onsite to provide training as it is needed and to undertake QA/QC work. While similar outcomes can be achieved from senior practitioners having less time in the field, it is often at the expense of additional time being required in the office, with greater dependence on second-hand observations. It is recognised that this finding was entirely situational and would not have occurred if the timing of the field program had not coincided with a global pandemic, however, it highlights that a very high-quality, extremely robust and defensible dataset can be created in the field. This project has shown that having more senior-level practitioners heavily involved in the logging and QA/QC can add substantial value to the client by driving efficiencies in the rock mass characterisation step of the geotechnical design process, thereby saving time and money during the modelling phase.

Acknowledgement

The authors would like to thank Rio Tinto Copper for the opportunity to work on the Winu project and its permission to publish this paper.