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CoalLog: the standard for collection recording storage and transfer of geological and geotechnical data for the Australian coal industry

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COALLOG: THE STANDARD FOR COLLECTION RECORDING STORAGE AND TRANSFER OF GEOLOGICAL AND GEOTECHNICAL DATA FOR THE AUSTRALIAN COAL INDUSTRY

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ABSTRACT: A standard has been developed to improve and upgrade the collection and coding of geotechnical data as part of geological exploration activity. CoalLog was developed by industry-based geoscientists and geotechnical specialists in response to outdated terminologies, non-translatable data coding, and con-conformances with relevant Australian and international standards for geotechnical investigation, testing, and reporting. The new standard will allow the industry to use geotechnical information efficiently and accurately, thereby minimising potential legal liabilities associated with non-conformance to recognised standards that are already in-place in the non-coal geotechnical sector. Adoption of this standard will also promote opportunities for a wider range of geotechnical specialists to provide services to the coal industry.

WHAT IS COALLOG

CoalLog (Larkin and Green, 2012) is the geological exploration information coding system that has rationalised and updated a wide variety of previous systems across the Australian coal industry. Several decades previously a standard GEODAS dictionary of geological terms had been introduced when computerised data management commenced. GEODAS codes were as abbreviated as possible in order to compress both quantitative data (e.g. depth and moisture content), and qualitative data (e.g. unambiguous visual-tactile description of a lithological unit), into the then-available punched-card line record length limit of 80 ASCII characters. The industry quickly adopted GEODAS, but competing and business interests were equally quick to customise the generic codes and formats. By 2010 many such enhancements had become unique to specific sites and organisational IT systems, but the resulting data sets were incompatible, non-transferrable, and deficient in clarity and meaning.

Modern geological data management systems provide complex functionality to access and manipulate information across a wide variety of information content, file specifications, and platforms. These systems continue to provide immense benefit to the industry and the advent of CoalLog will enhance this value. While there have also been significant improvements in drilling and geophysical logging capabilities, the fundamental processes of geological exploration have not changed. Rig geologists must use visual-tactile skills to observe and describe geological features accurately and quickly. Direct computerised field data entry is now becoming the norm, and the rig geologist must generate code accurately and quickly.

Most rig geologists are early-career professionals, usually working as contractors, who have to use the different "flavours" of data coding systems used by their range of clients. Most rig geologists have no exposure to geotechnical terminology and knowledge through either their original education or subsequent workplace mentoring by supervisors who have had equally minimal exposure.

Current geological data coding systems may be perceived to satisfy most of the industry's more organisation-specific immediate needs but several shortcomings lead to the development of CoalLog. Accuracy and meaning of coded information is no better, and perhaps systematically worse, than in the earliest days of GEODAS when there was more time and opportunity to check meanings and correct coding errors. The standard of visual-tactile description of geotechnical parameters is often so inadequate for due diligence purposes that the costs of original data collection are almost totally wasted. Transfer and checking of data from older exploration records for prospective areas can be computationally difficult and mind-numbingly tedious and frustrating to highly skilled individuals. All such shortcomings represent real costs to the business interests of the owners and operators involved.

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This situation has been recognised for some time, and the need for rationalisation was apparent from any multi-party viewpoint. CoalLog was developed though a process of consensus involving geological data, geotechnical, geophysical log data transfer, and geological data base management experts who originally convened at an invitational meeting in Brisbane in 2010. ACARP support was obtained in 2011 to provide documentation and an information roll-out which occurred in Singleton, Moranbah, Emerald, and Brisbane in February 2012. The Australian Institute of Mining and Metallurgy agreed to provide the web-hosting services.

CoalLog is therefore an industry-generated initiative, lead by competent, experienced, and recognised technical specialists across the coal mining industry, supported by ACARP and AusIMM, and continuing to be managed and enhanced by industry-recognised volunteer specialists. CoalLog is effectively owned and supported by the Australian coal mining industry.

CoalLog features a standard dictionary with a flexible method of implementation where the base content can be transferred electronically without loss of meaning. The structure of the coding process has been intentionally designed to allow flexibility for additional details required for implementation with particular platforms and organisations.

HOW COALLOG IS MANAGED

CoalLog is managed by consensus through a committee process. This has the advantage of decisions not being controlled or dictated by any individual or organisation, but the disadvantages of time taken to consider, approve, and implement any changes. The perceived concern of decisions being dominated by a particular party or viewpoint has not arisen to date, reflecting the commitment of individual professionals to technically sound but workable solutions that are acceptable to the interests of all the industry operators that are represented.

The CoalLog management process is best understood in terms of its evolution to date. This started with many discussions over a period of years during both commercially-sensitive work activities and open meetings of industry-based geologists, geotechnical and geophysics specialists, and personnel specialising in databases and modelling. Activities of the Bowen Basin Geologists Group, an ad-hoc organisation of persons interested in the geology of the Bowen Basin and sponsored by the Coal Geology Group of the Geological Society of Australia, provided regular opportunities in Queensland. Similar discussions and conversations took place within the New South Wales coal geology community. The June 2010 meeting in Brisbane invited representatives of all potentially interested parties, and volunteers were appointed to four sub-committees dealing with geology, geotechnical, geophysics, and database matters. Each of these sub-committees continues to meet as required to consider both its own direct subject matter as well as any multi-subject matters arising. Currently all CoalLog activities are coordinated and facilitated by two of the authors (Larkin and Green).

Most of the CoalLog sub-committee members and conveners are involved in Australian Coal Association Research Program (ACARP) activities in some manner. Once it became clear that the professional peer consensus process could deliver the CoalLog goals, ACARP support was obtained for preparation of a manual and workshops in early 2012 and ongoing AusIMM sponsorship was obtained for the CoalLog website. Further ACARP support has been requested for improvements to the manual and provision of training in the art and practice of geotechnical core logging.

Time devoted to CoalLog activities is fundamentally an in-kind contribution by the individuals concerned and the organisations they represent. Notwithstanding the highly competitive nature of industry-based organisations, the peer-regulated and industry-supported nature of CoalLog is robust and capable of providing continuation of leadership and productive outcomes as the contributions of individuals change over time.

WHY STANDARDISATION IS SO IMPORTANT

Generational succession is rapidly overtaking the individuals who implemented and nurtured computerised data collection from its earliest beginnings. Historical reasons for changes to coding for particular geological or geotechnical subjects have been forgotten, and computational limitations or personal conventions are rapidly becoming outdated or meaningless.

Corporate and statutory governance purposes generally requires due diligence studies and reporting in compliance with the JORC standard (JORC, 2004). Manipulation and transfer of complex data sets generates formatting, coding, and output requirements where incompatibility issues have consumed an increasing proportion of the time and costs of specialists. CoalLog is designed to remove such demands, and has been recognised by the New South Wales government as meeting its requirements for statutory reporting in paperless format. A similar outcome is under discussion in Queensland.

JORC-compliant reporting is based on levels of technical assessment. Business finance and insurance is based on the accuracy and clarity of information disclosure. Specifically, geotechnical parameters are assessed from both geological and geotechnical data, and an "economically mineable resource" (JORC, 2004 Para. 28) implies that mining is possible "under reasonable financial assumptions" based on due consideration of geotechnical matters. Geotechnical assessment is in turn based on recognised measures of risks from ground-related hazards. If forecasts are significantly in error because of coding errors or misinterpretation of information, or if damages result from failures involving inadequate geotechnical assessment, the resulting costs may have legal liabilities affecting both organisations and individual professionals. Litigation includes focus on compliance with recognised standards and tests of reasonable judgement.

CoalLog therefore has two forms of implied legal status. It has to be as unambiguous and accurate as possible to all parties, but the attribute descriptions and meanings that are used must also be as compliant as possible with recognised Australian or international standards. Consideration of relevant geotechnical codes was a significant aspect of CoalLog development.

PRACTICALITIES OF GEOTECHNICAL DATA COLLECTION

Exploration for coal is primarily based on drillholes supported by geophysical traverses, but can include mapping of exposures in small pits or full-scale mine excavations. Near-surface, weathered, or non-coal bearing units do not include coal of economic significance but are usually zones of critical geotechnical and project significance. Casing is required particularly when drilling through weak near-surface materials that may also be water-sensitive.

Logging of all subsurface materials requires rapid and accurate descriptions based on visual-tactile observations. Soils may be described geologically as unconsolidated sediment, which is a term totally unrelated to geotechnical meaning or characteristics. The CoalLog codes were therefore designed to support unambiguous geotechnical as well as geological description. Most exploration drilling is by open-hole or chip-hole methods where logging is based on collection and description of cuttings, hopefully with due allowance for fall-in and flush lag-time. Such logging may be inadequate for JORC-standard reporting that involves geotechnical assessments unless additional information can be measured by testing or inferred from accurate description. CoalLog has been designed to minimise errors and under-reporting of near-surface geotechnical data particularly where casing has been used.

Cored drillholes provide maximum geological and geotechnical information. Cutting and retrieval of core causes damage through vibration, stress relief, and cutting fluid erosion, while surface exposure will result in irreversible deterioration if the core is allowed to dry. All of these factors affect what is observed and must be kept in mind by the rig geologist, particularly when wireline coring may recover core faster than the rate at which observations can be recorded. The CoalLog core description process provides for quickly and accurately recording a basic level of key geotechnical data. CoalLog also provides an alternative and more detailed core description process that follows the same protocols but allows for more detail to be coded where the purpose of the drillhole is primarily geotechnical.

Coal cores require particularly detailed geological description and sampling because of product processing and quality considerations. In contrast, coal may be merely another rock material in terms of both open-cut and underground mining assessments that are focussed on rock mass and rock structure strength and deformation responses. An innovation of CoalLog is the recording of depth intervals as rock mass units, as distinct from lithological units. An alluvial floodplain overbank facies, for example, may consist of several tens of metres of a repeated sequence of laminated siltstones and sandstones including thin to thick sandstone bands. Full lithological detail would require complex description, but CoalLog allows such an interval to be described alternatively as a single rock mass unit having essentially uniform geotechnical parameters, thus enabling vital field time to be focussed on defect descriptions and sampling.

Many descriptions may be updated or changed based on quantitative laboratory techniques ranging from microscopy to tests of physical and chemical parameters. This may occur at a later time in a very different place, and involve other personnel who may have no knowledge of the actual field conditions or contact with the field geologist. Typical examples are the mean and range of particle sizes for soil or sedimentary rock, or a strength indicator of the material such as the UCS for rock or the plasticity for a cohesive soil. Over the decades of GEODAS enhancements, the meaning of many strength-related codes has been so diluted as to be uninterpretable. CoalLog has therefore been structured with a common standard based on updated geotechnical coding, but in such a manner that a particular organisation may still utilise its "legacy" codes.

Calculations of individual rock defect strength, rock mass strength, and even ground support requirements can now be made almost automatically using freeware or customised geotechnical software. In developing CoalLog, careful attention was therefore paid to facilitate observation and coding of geotechnical data in a reliable manner to facilitate subsequent calculations.

COMPLIANCE WITH STANDARDS AND GOOD PRACTICE

Coal mining is driven by business considerations, for which geotechnical considerations provide fundamental risk controls. Mining operations may result in potentially fatal consequences for hazards where the associated risks are not effectively controlled. If geotechnical advice and design actions are inadequate because of content dilution or loss of meaning, then there may be associated liabilities which are most likely to be discovered and determined though adversarial and expensive litigation. Insurance cover for coal mining activities is complex and dependent on the acceptability to the insurer of the operator's risk management processes. This means that business value is determined ultimately by the reliability of the information upon which critical decisions are made. From a legal perspective, inadequate data and design assessments are matters of negligence, whereas non-compliance with accepted standards may be a matter of negligence or, in the case of deliberate non-compliance, even professional misconduct.

In Australia all geotechnical information is expected to comply as far as possible with the site investigation standard AS 1726 (1993), which references both descriptive and test result information from related geotechnical testing standards particularly AS 1289 (2000) but also AS 1141 and AS 4133. AS 1289 has particular significance for description of grainsize ranges, where geological description of grainsize has historically followed very different measurement protocols, and descriptions of material strength, where many different scales have been used historically by a diverse range of interest groups.

For compliance with AS 1726, CoalLog adopted a particle size terminology that is essentially logarithmic in its subdivisions, but which is based on the accepted world-wide standards and practice of the geotechnical community. Fortunately, in the coal industry where sedimentary rocks are of greatest interest, it was readily possible to merge accepted size-related geological terms (silt, sand, gravel, pebble, cobble etc) with the AS 1726 geotechnical format, and in the process provide a single consistent and measurable reference for geologists at the cost of minor adaptation to the CoalLog codes.

Also in accordance with AS 1726, CoalLog description of weathering (oxygenated and therefore ground surface-related chemical and physical change processes) is separated from and not based upon assessment of strength which has to be described separately. CoalLog also provides separately for description of alteration, which may result in observationally similar features to weathering, but is attributable to geochemical and physical changes that are not related to near-surface processes. Based on observations, the qualifying codes for alteration follow the same pattern as for weathering.

In AS 1289 there is an overlap between measures invoked in the description of hard cohesive soils and extremely low strength rocks. Provided a reasoned observation is made, this overlap has no geotechnical significance. Reasoned observations that are familiar to geotechnical specialists but less familiar to geologists can also be made for both cohesive and cohesionless soils.

However, AS 1726 uses the Point Load Strength Index as a descriptive measure of rock material strength, whereas in current geotechnical practice the more fundamental measure of Uniaxial Compressive Strength (UCS) is favoured. Coal measures rocks have been the subject of a number of UCS-based descriptive scales with significance for various mining activities and ground support requirements (e.g. BS 5930:1999; Anon, 1977). Aspects of some of these scales have been captured and then diluted in legacy versions of GEODAS codes, to the extent that pre-CoalLog rock strength descriptions are geotechnically unreliable unless supported by laboratory test data. The UCS-based CoalLog scale for rock material strength, which diverges from AS 1726, deliberately adopted clear and meaningful classes relevant to coal mining practice, together with meaningful visual-tactile methods for field description purposes. The UCS ranges for the CoalLog strength codes are illustrated in Figure 1 which also shows alternatives which were not adopted for various reasons described above.

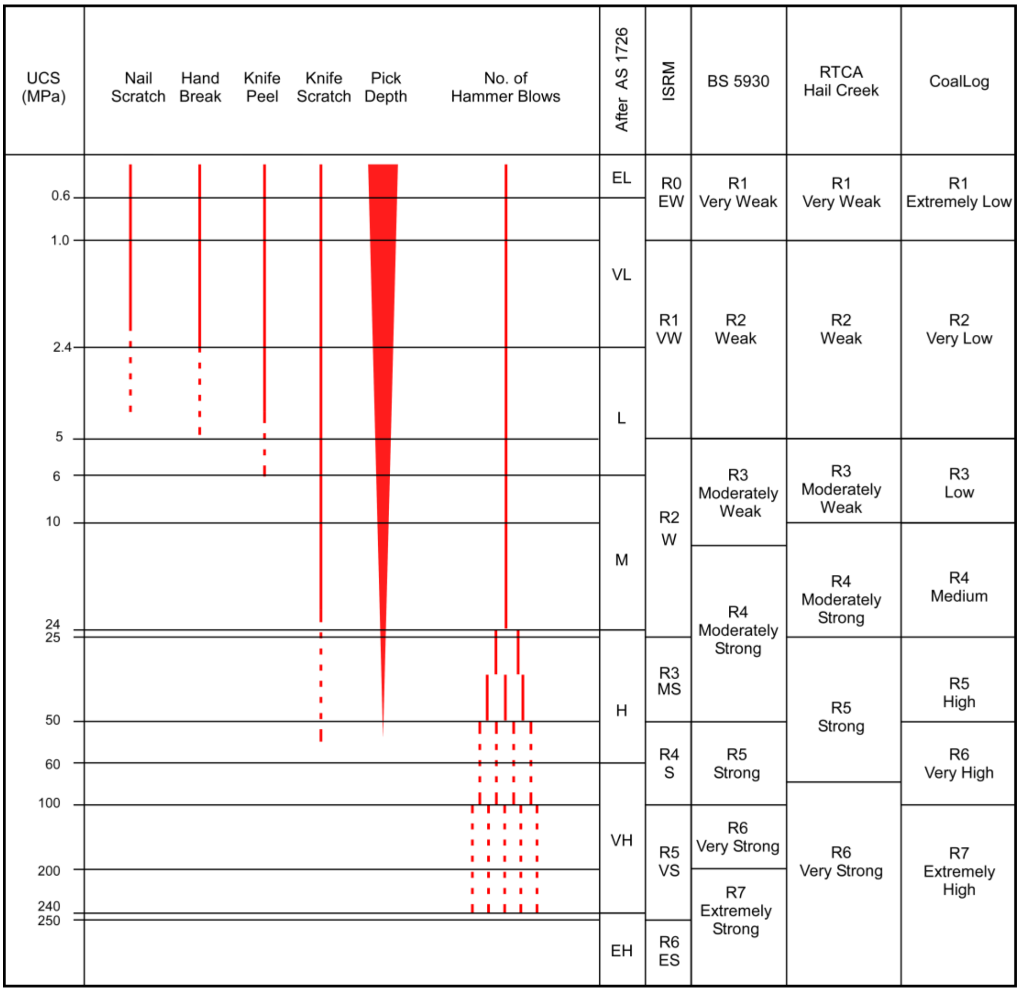

Figure 1 - CoalLog visual-tactile descriptive scale for UCS-based strength classification

Rock defect shear strength requires data based on detailed observation of surface shape, roughness, infill, and wall material. Several geotechnical models for defect strength may be used in later assessments provided that adequate detail is logged. CoalLog provides for a standard level of defect detail, which is recorded on the standard coding pro-forma and which allows only for simplified geotechnical interpretation. An alternative, detailed geotechnical pro-forma can be selected which allows for observation parameters such as roughness and JCS in a format for more specialised later assessment. CoalLog allows either the standard or the detailed pro-forma to be used for a particular corehole, but not both.

The particle-size and strength descriptions represent a significant change from past practices, for some, and are considered essential to comply with application of existing standards and good practice. Best geotechnical practice also requires unambiguous separation of observation and interpretation, which is more difficult for geologists since the recognition and description of interpreted environments and processes is an essential skill. Separation of weathering or alteration and strength observations is necessary best-practice for which both geologists and geotechnical specialists should be mindful. Codes for strength observations were specifically designed in CoalLog to maximise meaningful observation-based description, and are being considered as part of the current revision of AS 1726.

BASE DEPTH AND THE DILEMMA OF CORE LOSS

Previous GEODAS coding based on depth intervals has been replaced in CoalLog by data records described by base depth and thickness. This allows more flexibility for describing different types of depth-related attribute ranging from rock mass unit to lithological unit and zero-thickness horizon. Since almost all field data entry is now computerised, this also allows for powerful self-correction and prompting for missing or incomplete descriptions.

Base depth also allows for computerised handing of actual depths and thicknesses in cases of drillhole deviation from verticality and non-vertical drilling. Full core orientation is the exception rather than the practice in coal exploration, although verticality is often routinely measured when the hole is surveyed geophysically. A protocol is required for measurement of base depth but the protocol is not specified in the CoalLog standard. Best-practice is to fit obviously rotated fragments in the splits and then mark a reference line at which base depth is measured. The rig geologist remains responsible for reconciling measured base depths against drillers' depth records, and post-processing enables marker depths to be adjusted based on geophysical reconciliation.

The sole function of CoalLog codes is to describe attributes with respect to base depth. The angular orientation of features with respect to the core axis can be measured in the field. CoalLog coding is based on a simple premise: angles are measured as departures from a plane perpendicular to the core axis at any base depth. This facilitates automated post-processing of actual drilled depths and orientation relative to drillhole axis, and includes the additional codes that are recorded for fully oriented coring.

Core loss remains a dilemma. There are many reasons for losses, all related to the mechanical performance of the drilling string and the locally damaging effects of the drilling process on the material being penetrated. Sometimes unrecovered stubs are retrieved in the next run and sometimes drilling and flushing removes entire sections of weak material. Driller "feel" and drill rig operating parameters may provide additional clues that can be recorded as comments. In some cases reconciliation with geophysical records is sufficient to allocate core losses accurately in terms of base depth and thickness. CoalLog provides a single code to represent the base depth and thickness of a core loss interval, and further correction and interpretation is then a matter for post-processing based on the skill of and drilling observations by the rig geologist.

RECONCILIATION WITH GEOPHYSICS

Routine geophysical logging is an essential component for post-processing data from open-hole or chip-hole drilling, which is otherwise limited to observations of cuttings that are aggregated over usually 1m depth intervals. Geophysical data sets are normally transferred and post-processed for geological and geotechnical purposes using standard LAS formatted files which are base-depth records of measurements from the tools that are deployed. LAS files also include header records which explain the format of the data records. There is no current standard for the names of various tools and the format of headers. While this is not an impediment for use of CoalLog, further development of the standard is under way to implement a standard for LAS file headers and data record handling that is fully compatible with the CoalLog drillhole header formats and data management standards.

FUTURE DEVELOPMENTS

Vendors of field logging software have been quick to recognise and adopt CoalLog. It is expected that industry implementation will take some time, and that individual organisations will have to make decisions as to how and when CoalLog can be adopted based on their own interests and logistical considerations.

The CoalLog standard is subject to active management. Since its original release in 2011 some minor corrections and amendments have been considered and adopted where appropriate. Further development is expected with respect to data transfer standards and handling of geophysical LAS files. It is expected that Queensland will inevitably follow New South Wales in adopting a policy for submission of statutory data and reporting in fully electronic format based on the CoalLog standard.

The recent upsurge in coal exploration and project evaluation demonstrated that the industry faces a critical shortage of geotechnical resources. Partly this can be attributable to business cycles and generational change, but part is also related to the almost exclusive "ownership" of geotechnical data gathering activity by rig geologists who often lack the necessary training and understanding to be able to observe and describe geotechnical attributes accurately. Within the wider geotechnical community is a considerable resource of specialists who have been under-utilised in coal exploration geotechnical activities. The advent of CoalLog has provided a platform for logging using geotechnical standards that already exist outside of the coal exploration industry. The CoalLog standard may yet be further developed for adoption and integration into general geotechnical logging methodology and software standards.

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