Title: Development of a technically consistent, qualified lithostratigraphic database for the Yucca Mountain Project.
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Introduction

Studies of Yucca Mountain, Nevada, as a potential geologic nuclear-waste repository began in the late 1970s and continued to 1988 when the U. S. Nuclear Regulatory Commission determined that the quality assurance (QA) programs in place were not adequate and demanded restructuring to a new QA program. The new QA program was accepted in 1989, but many activities did not resume until new procedures were in place, until the early 1990s. These two generations of QA programs have resulted in a highly convoluted assignment of qualified (Q)-status for much of the data related to boreholes. In the simplest case, any data that came from boreholes drilled before 1989 had been assigned non-qualified (non-Q) status, and all post-1989 boreholes (none of which were drilled until 1991) have been assigned Q status. This pre- and post-1989 distinction in Q status of borehole data has meant that lithostratigraphic descriptions and contacts from the pre-1989 boreholes have been classed as non-Q, and any models¹ that used these data also carried the non-Q status (R.W. Clayton, W.P. Zelinski, and C.A. Rautman, TRW Environmental Safety Systems, Inc., written commun., 1997). This Q-status barrier has also limited the amount of lithostratigraphic work done on the pre-1989 boreholes because of the drive to produce Q-status descriptive reports that contain only Q-status data. A parallel and critical concern that arises from such a long history of data collection is the consistent identification of lithostratigraphic units. In the spring of 1996, an intensive effort began to re-examine 11 lithostratigraphic contacts in boreholes. This work was expanded in 1997 to include as many as 50 lithostratigraphic contacts in 80 boreholes. All this work has been done under the post-1989 QA program and emphasizes technically consistent contacts and the Q-status of each contact rather than carte-blanche assignment by borehole.

Strategy for determining technically consistent and Q-status lithostratigraphic contacts

Technically consistent and Q-status lithostratigraphic contact picks can best be attained by using (1) a small, highly integrated, group of geologists that specialize in the volcanic stratigraphy at Yucca Mountain, and (2) identification of contacts must be based on Q-status data that occurs in as many boreholes as possible to provide continuity of types of data. After reviewing all available types of data, it became evident that borehole geophysical logs provide one of the most commonly available data sets in most boreholes. Almost all post-1989 borehole geophysical log data have Q status, and based on standard industry practices and available documentation, it appeared possible to qualify the pre-1989 borehole data. In 1995, a Borehole Geophysical Data Technical Assessment Committee convened to re-examine the Q-status of borehole geophysics from the pre-1989 period; that assessment was based on the older logs having "procedural equivalency" with post-1989 procedures and did not evaluate any technical criteria (L.L. Cuba, TRW Environmental Safety Systems, Inc., written commun., 1995). Of the initial 1011 non-Q borehole geophysical logs examined, 766 were reassigned Q status. The stage was set to use the newly reassigned Q-status geophysical logs to produce Q-status lithostratigraphic contact picks. Even after the reassignment of Q-status for many pre-1989 geophysical logs, a highly complex configuration of boreholes that have Q and non-Q status geophysical data, core, and cuttings remained. Combinations of Q and non-Q status geophysical logs, core, and cuttings are shown in figure 1 where boreholes with all three types of data (logs, core, and cuttings) will plot in a triangle, boreholes with only two types of data will plot along the side of a triangle, and boreholes with only one type of data will plot on the apex of the triangle. Forty-five boreholes provided continuous core (but only 26 of those have geophysical logs), 3 have core from only about 50 percent of the hole and partial geophysical logs, and 28 have cuttings with only spot core and variable coverage with geophysical logs.

Compilation and display of data

A wide variety of data sources provides lithostratigraphic and geophysical data, although the amount of data varies greatly from borehole to borehole. Data sources include lithologic descriptions of core and cuttings, photographs of core, video recordings of core and borehole walls, map relations of lithostratigraphic units and faults, properties of core or cuttings, geophysical logs, quantitative mineralogy,

and logs of fractures. These data are typically presented independently as selected topics, or as with geophysical logs, as large, highly informative but very complex plots at scales of 600:1 to 2400:1.

In order to expedite and standardize the review and presentation of lithostratigraphic, borehole geophysical, and core-property data, both an Excel* macro and workbook have been developed and are collectively referred to as CONTACT. These two Excel-based products provide a standard, integrated format for reviewing contact depths and available geophysical log data for each borehole. The macro quickly produces a set of five plots for any depth interval defined by the user with traces for geophysical logs and individual symbols for core data (an example sheet of charts is shown elsewhere²). Scales of any of the five plots can be modified to accentuate subtle geophysical log characteristics. A CONTACT workbook, developed for each borehole, contains the standard diagnostic geophysical logs of density, porosity, resistivity, and saturation and where available the corresponding values determined on core. These four types of data are plotted as individual charts. A fifth chart is used to display one of several types of data (if available) that include magnetic data, velocity data, gamma-ray, and potassium, uranium, and thorium data calculated from spectral gamma-ray data. Additional charts of nongeophysical log data such as quantitative mineralogy, thermal and mechanical properties, fracture data, and non-Q and technically suspect data can be made after these data are entered into the workbook. The workbooks have been designed with standardized data sheets for consistent presentations of contact depths, lithostratigraphic features, geophysical data, and core-measurement data such that a collection of workbooks can be queried to extract specific information. Although each workbook is a complete package, it also acts as a piece of a much larger database. The current version of the workbook has 50 lithostratigraphic contacts but can be customized to accommodate different numbers of contacts. The goal of compiling and producing this CONTACT workbook and program is to (1) use the charts to aid in determining distribution of and relations between various types of data, (2) assist in picking geophysical and lithologic contacts, and (3) enhance visual integration of all borehole data. A schematic representation illustrates the method of data compilation, integration into the workbook, evaluation, and picking of a contact (figure 2).

Challenging aspects of the task

The type and distribution of data, whether Q or non-Q status, are variable within and between boreholes and form one of the major challenges to identification of lithostratigraphic features and units. Some closely spaced boreholes have core but no geophysical data, and others have geophysical data but no core. In the borehole pair UZ-14 and UZ-1, for example, UZ-14 has Q-status core and property measurements on core, and although a full suite of geophysical logs was collected in the lower part of the borehole, only a gamma-ray log was run inside casing in the upper half of the borehole. Borehole UZ-1 has only non-Q cuttings and a non-Q density log but does have Q-status resistivity, epithermal neutron, and gamma-ray logs. In the borehole pair A#1 and B#1, A#1 has non-Q core and measurements and has Q-status gamma-ray and magnetic-susceptibility logs in the upper part of the borehole, but non-Q density, Q-status induction, thermal neutron, and p-velocity log in the lower half of the borehole. Borehole B#1 has only cuttings for the upper half with core below and a complete suite of geophysical logs except for the upper 100 m.

Depth registration of data can be problematic. Discrepancies in depths result from (1) poor depth controls on wireline tools, (2) somewhat arbitrary methods for assignment of non-recovered core intervals, (3) failure to recover core during the drilling run that cut it, and (4) incomplete understanding of cuttings during the drilling cycle. These complications create multiple variables that can result in nonunique solutions, but fortunately the depth range in question is typically less than that of a drilling run interval (commonly 5 to 10 ft long runs).

One of the major limitations in the pre-1989 borehole geophysical data is that density logs in many boreholes remain non-Q, although the data have been used because of their overall technical quality. Density is the principal log for identifying contacts, and without it, other logs must be used. Density is a fundamental element in the calculation of porosity. Without Q-status density data, calculated porosity values are also non-Q. The cost of re-acquiring all of the borehole geophysical logs from the pre-1989 boreholes is most likely prohibitive. Therefore, the existing density data should be treated as unique data, and based on their technical quality, a method should be devised to re-assign these logs to Q status.

Conclusions

An integrated approach for establishing technically consistent and Q-status picks of lithostratigraphic contacts can be based primarily on the correlation of lithostratigraphic features to geophysical log signatures. The CONTACT workbooks and macro provide a powerful and extremely portable tool for visualizing the spatial relations of geophysical log data, properties measured on core, and quantitative mineralogy, as well as descriptions of lithostratigraphic features and resulting interpretations. The CONTACT workbook has been invaluable during the evaluation of lithostratigraphic contacts. As a technical and management tool, it provides rapid assessment of the available data, identification of technically suspect parts of the data, and the Q status of the data.

- * The use of trade, product, industry, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References

1. Buesch, D.C., Nelson, J.E., Dickerson, R.P., Drake, R.M., Spengler, R.W., Geslin, J.K., Moyer, T.C., and San Juan, C.A., 1996, Distribution of lithostratigraphic units within the central block of Yucca Mountain, Nevada: A three-dimensional computer-based model, version YMP.R2.0: U.S. Geological Survey Open-File Report 95-124, 61 p.
2. Buesch, D.C. and Spengler, R.W., in press, Detailed correlation of lithostratigraphic and borehole geophysical log data for identifying contacts at Yucca Mountain: American Nuclear Society, La Grange Park, IL, 60526, 1998 International High-Level Radioactive Waste Management Conference, Las Vegas, NV, May 11-14. (this volume)

Figure 1. Combinations of Q and non-Q (nQ) geophysical log (GLog), core, and cuttings data in boreholes at Yucca Mountain.

Figure 2. Process followed to determine correlation of lithostratigraphic contact and geophysical log data.

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