OCEAN DRILLING PROGRAM

Report of a Workshop on

ODP LOG DATA QUALITY CONTROL

Washington, DC
April 13-14, 1989

by
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SUMMARY

In pursuance of a recommendation of the JOIDES Downhole Measurements Panel, a meeting of former JOIDES Logging Scientists was held on April 13 and 14 in Washington DC to review the acquisition, storage and shipboard processing of wireline logging data collected during the first four years of the Ocean Drilling Program. Also in attendance were representatives of the Borehole Research Group of the Lamont-Doherty Geological Observatory (LDGO), Ocean Drilling Program Operations (Texas A&M University), Schlumberger Offshore Services (Houston), the JOIDES Downhole Measurements Panel (DMP), and the Joint Oceanographic Institutions (JOI). The stated purpose of the workshop was "to evaluate the impact of shipboard logging practices on log data quality by identifying problematic areas and recommending ways in which these might be improved".

The following recommendations were formulated by the workshop:

1. Data quality rather than quantity should be the overriding priority in log data acquisition: present time restrictions do not allow both to be achieved satisfactorily.

2. Logging programs should be identified <u>after</u> the thematic objectives have been formulated but <u>before</u> the provisional leg structure is established. Thereafter, logging should comprise an integral part of the planning process.

3. Co-chief scientists should be contacted by the JOIDES DMP shortly after being named to be made aware of the role of downhole measurements in addressing the scientific objectives of their leg. DMP should consult the Co-chiefs on any subsequent revisions to the DMP logging recommendations.

4. The JOIDES logging scientist should be identified and trained at the earliest possible stage in the pre-cruise planning process. All prospective JOIDES logging scientists should attend LDGO for at least one week. Properly scheduled

training is essential in view of the technical complexity of the downhole measurements program.

5. DMP in consultation with LDGO should formulate a more specific job description for the JOIDES logging scientist.

6. Because of the remoteness of the shipboard location, LDGO should particularly ensure that at least one logging scientist is completely capable of operating and maintaining shipboard systems for data processing and specialty tool data acquisition. These should be simplified so that the JOIDES logging scientist can fully participate in the routine log processing and analysis.

7. The LDGO logging scientist should make a presentation to the shipboard party early in a cruise to outline the scientific purpose of the logging program.

8. Adequate time for hole conditioning should be included in all leg schedules.

9. For a site where poor hole conditions can be anticipated, time provision should be made at the earliest possible stage of planning either to deploy the side-entry sub assembly (SES) without detriment to the scientific logging schedule or to drill a separate hole dedicated to logging at that site. (see # 10)

10. The SES should be run in all cases except where hole conditions turn out to be superior.

11. Development of the new SES is essential in view of its safety, operational, and time-saving benefits, relative to the existing facility.

12. The wireline heave compensator (WHC) must be fully maintained by the time-shared SEDCO mechanic. Routine standard testing of the WHC should be undertaken at least six-monthly. Analysis of accelerometer data from the formation microscanner (FMS) would serve in lieu of routine testing.

13. LDGO should be formally assigned a part-time technician for shipboard electronics support.

14. The degradation of data from the neutron porosity and sonic tools, caused by the new standard tool combinations, is

unacceptable in view of the emphasis on data quality. Where high quality neutron porosity and sonic data are deemed essential, provision should be made for running separately an eccentered tool combination and a centered tool combination taken from the seismic stratigraphy/porosity string. This will require an additional logging run.

15. A composite plot of total natural gamma, induction resistivity, lithodensity and sonic logs should be prepared and distributed as soon as possible after completion of the first logging run, subject to appropriate quality control criteria. This would ultimately require data transfer from the CSU to another shipboard system. A system should be developed to read raw CSU field tapes directly into a processing system to facilitate the rapid presentation of primary field data.

16. The shipboard whole core scanning facility should be extended to include natural gamma-ray spectroscopy and, if possible, induction resistivity, for correlation with and calibration of logs.

17. The TAMU computer users group are urged to give high priority to the implementation of a system to merge wireline log data and core barrel data on board ship.

18. A software user-directory should be compiled of all shipboard systems, to include personal and mainframe computers, and should be distributed to the scientific party prior to each leg.

19. The post-cruise integration of log and core data from selected legs should be undertaken, with institutional support, to refine further the wireline log analysis.

20. An archive of tool response characteristics should be established at LDGO: the logging subcontractor should be required to provide sufficient information to enable log response to be properly simulated. LDGO should approach the subcontractor to establish the format of this archive.

I. INTRODUCTION

Since the inception of the Ocean Drilling Program (ODP) in 1983 the role of downhole measurements has steadily grown to become an important and integral part of the overall scientific drilling effort. This growth can be attributed to two complementary factors; an increasing rate of acquisition of wireline logging data and a wider appreciation of the scientific benefits of downhole measurements as a whole. This most satisfactory state of affairs is due to the concerted efforts of the ODP wireline logging contractor (LDGO), the wireline subcontractor (Schlumberger) and the scientific, engineering and operational staff of ODP. As a result of these efforts, ODP scientists have access to the most advanced routinely run logging suite in the world today. These data are providing vital pointers in our drive to learn more about the earth's structure and history as it is revealed beneath the oceans.

Motivated by these successes, it was considered appropriate to re-examine the status of logging data acquisition within the ODP, in anticipation of even greater usage of these data in the future. To this end, a meeting hosted by JOI was convened in Washington DC on April 13 and 14, 1989. All former JOIDES Logging Scientists were invited. Also in attendance were representatives of the Borehole Research Group (LDGO), Ocean Drilling Program Operations (Texas A&M Univ.), Schlumberger Offshore Services (Houston), the Downhole Measurements Panel of ODP, and the Joint Oceanographic Institutions. The stated purpose of the workshop was "to evaluate the impact of shipboard logging practices on log data quality by identifying problematic areas and recommending ways in which these might be improved".

Participants from LDGO, TAMU, and Schlumberger were specifically requested to be seagoing personnel, in order that the workshop be able to concentrate on problems associated with the tasks of the logging scientist at sea. Eight former logging scientists were able to attend, representing eleven of the twenty three legs that had been completed at the time that the meeting was announced. The two representatives of LDGO totalled eight drilling legs, Schlumberger six, and the Texas A&M/ODP Engineering representative had been aboard eight ODP legs and numerous DSDP operations.

The discussions were wide ranging and touched upon every aspect of the wireline logging program including pre-cruise planning, strictly mechanical questions such as the storage and staging areas for logging tools, digital data processing aboard ship, and the integration of wireline logging data with other ODP studies performed during the course of a cruise. Broadly speaking, the recommendations of the Log Quality Workshop can be broken down into several overlapping categories: logging philosophy, cruise planing, duties of JOIDES and Lamont wireline logging scientists, logging operations, and data handling. Participants were in unanimous agreement that the ODP logging program has been a success. The following discussion reflects the opinions of the panelists on the subject of how to make a good program better and is not to be construed as criticism of the accomplishments of the program to date.

II. LOGGING PHILOSOPHY

Downhole measurements have a unique position within the context of an ocean drilling cruise because the measurements made are in direct competition for time with sample recovery through drilling and coring. This has imposed limitations on the wireline logging program that can cause conflicts between the twin goals of (a) providing timely and useful data to the scientific party during drilling operations and (b) acquiring a consistent (from site to site and leg to leg) set of *in situ* geophysical measurements which can be archived for the use of future scientists. This conflict will not be resolved in the near future because the number and complexity of wireline logging sondes and other downhole tools continues to expand, calling for increasingly greater amounts of time dedicated to logging if all possible measurements are to be made at all sites. Given that it will not be realistic to expect sufficient logging time to do a complete job, the workshop panel discussed the several options and implications of carrying out a logging program within a limited time budget.

All panelists were in agreement that data quality rather than quantity should be the overriding priority in wireline operations since the present time restrictions do not allow for both. In particular, it was suggested that tools which needed to be centered were being lowered on the same string as others which needed to be pressed against the borehole wall. The degradation of the data that this mode of operation entails was viewed as unacceptable. While the degraded data might be of some immediate use on the cruise for unit delimitation or other purposes, it would lose value rapidly over time in the archival sense since the operational parameters that a future scientist might require will not be known. It was agreed that the quantity of data must be sacrificed to quality even if this means that some sites might have little coverage.

The topic of tool response was discussed at length. A list of presently available tools was presented by the Schlumberger representative (Table 1). The problems facing scientific logging are different from those facing the petroleum industry. Many of the rules of interpretation currently used in industry are related to sedimentary rocks and are empirical, or semi-empirical, in nature. They are "correct" in a statistical sense because of the large number of measurements from which they derive. Often these "laws" (Archie's Law, Wyllie's Equation) are inappropriate for scientific logging. Scientific logging will never be able to rely on statistical calibration of logging tools, and so must be able to understand logging measurements based on the physical principles of tool operation.

Table 1. Tools Presently On Board Ship
January 1989

2	Phasor Induction Tools (DIT-E)*
1	Digital Sonic Tool (SDT)*
2	Long Spaced Sonic Tools (LSS)
1	Litho-Density Tool (LDT-C)
1	Hostile Litho-Density Tool (HLDT-C)
2	Telemetry Communication Cartridges (TCC-B)*
1	General Purpose Inclinometer Tool (GPIT)
3	Natural Gamma Ray Spectrometry Tools (NGT/ACT)
2	Dual Compensated Neutron Tools (CNT-G)*
2	Gamma Ray Spectroscopy Tools (GST-A)
2	Well Seismic Tools
2	High Resolution Temperature Sondes
2	Dual Lateral Logging Tools (DLL)
2	Mechanical Caliper Devices (MCD)

* Introduced in last 2 years.

One of the disadvantages of utilizing state of the art tools from a commercial contractor is the reluctance of the contractor to release technical details concerning the design of the tool. The panel felt that this information is essential to scientific drilling programs in general and ODP in particular, since logging is most often performed in "non-standard" environments. Several of the panel members have had some success in obtaining this sort of information from logging companies. The technical data have been been used to model tool response and gain a better understanding of well log interpretation in igneous and metamorphic rocks.

Beyond the immediate value in interpretation that is afforded by an understanding of the function of the logging tools, there is also the effect that lack of this information will have on the value of wireline data as a scientific archive. It was noted that different versions of tools which the contractor has used in the past to make measurements of properties such as porosity or resistivity do not yield the same values in the same holes. The researchers of the future must be able to understand why these differences exist.

While there was general agreement on the value of making tool design criteria available, there was less unanimity in how this might be accomplished, given the fact that some of the tools were protected designs. Suggestions ranged from abandoning the most high-tech measurements in favor of more basic technology which would be open to all, to getting an agreement that the information would be made available at some date in the future, after individual tool designs were taken out of service. The agreed recommendation was that LDGO should contact Schlumberger with a view to establishing a tool response archive. This archive need not contain all design data for tools, but it must provide enough information to allow the simulation of tool response in non-standard environments.

III. PLANNING

The logging scientists expressed some concern over both the role of logging within the structure of an ODP leg and with the somewhat ill-defined duties of the JOIDES well logging scientist. Particularly amongst participants on earlier cruises, it was felt that logging was seen as an "add-on" to the scientific program rather than an integral part of the scientific plan. It was noted by more recent participants and by Downhole Measurement Panel members present, that time for well logging is now being incorporated in leg schedules at a much earlier date in the planning process than had originally been the practice. Thus, logging ought to be an integral part of the planning process.

Panelists saw the job of coordination of the logging program with other aspects of the cruise as something that the DMP should carry out in consultation with the Co-Chief Scientists. Presentations on the scientific objectives of the logging program should be made by the LDGO logging scientist early in the cruise. These should heighten the awareness of shipboard scientists, including Co-chiefs, that logging is an integral part of the scientific drilling program.

Every logging scientist felt that there was not enough time allotted to logging in order to perform all of the measurements properly. If this condition continues, it was seen as an advantage to name a logging scientist as early as possible in the forming of a scientific party so that he/she might be able to work in concert with LDGO and the chief scientists to establish the best suite of planned measurements that might be accommodated in the cruise schedule. At the same time, early notification of selection as a logging scientist will allow the individual the opportunity to visit LDGO for a week of pre-cruise training and familiarization with both the logging system and the goals of the upcoming cruise.

IV. JOIDES SCIENTIST DUTIES

The particular duties of the JOIDES Logging Scientist were not well defined in the eyes of the panel members. LDGO representatives presented the current understanding of the Borehole Research Group, summarized in Table 2, but this does not indicate the specific duties of the JOIDES Logging Scientist. It was felt that there was a problem in the fact that much of the routine well log data processing was left to the LDGO scientist. In practice this means delays aboard ship, since the LDGO Logging Scientist also has the primary responsibility for monitoring data acquisition. The logging data are often not ready for several days after logging has ceased, seriously affecting the ability of the logging scientists to examine those data while the rest of the scientific party are still forming their respective site reports.

Another criticism of the JOIDES Logging Scientist position was that it has been filled in the past with scientists who have a single interest, and who have not participated in the routine aspects of the logging program. The panel felt that both the time lapse between logging and subsequent data distribution to the scientific party, and the participation aspects of the JOIDES Logging Scientist, could be remedied by writing a more specific definition of the JOIDES Logging Scientist position, to include both routine data processing and documentation duties. All of the other scientific positions aboard an ODP cruise demand a rigorous schedule of assigned work (eg. core description, physical properties or paleomagnetic measurements) and it was felt that the logging scientist position should not be treated differently.

The working group proposed that a composite plot of some of the basic logs from the first logging run at a site should be prepared and distributed to the scientific party as soon as possible after the completion of the first run. Given the responsibility of the LDGO Logging Scientist to work with Schlumberger during logging,

Table 2. Logging Scientist Duties

RESPONSIBILITIES OF THE LDGO LOGGING SCIENTIST:

Schlumberger Data Acquisition: Supervision and Quality Control
Specialty Tool data acquisition and Processing
Data Reformatting
Depth Shifting and Merging
Log Editing
Sonic Waveform Processing
Geochemical Log Processing
Preparation of Final Plots

RESPONSIBILTIES OF EITHER THE JOIDES OR THE LDGO LOGGING SCIENTIST:

Authorship of Part A Chapters
Qualitative Interpretation of Lithologic Units
Qualitative Interpretation of Speciality Tool Data
Comparison of Log and Lab Measurements of Physical Properties
Intersite Correlation Via Logs
Generation of Synthetic Seismograms

NON-LAMONT RESPONSIBILTIES:

Seismic Interpretation Linked to Core and Log Data
Detailed Interpretation of Speciality Logs
Interpretation of Geochemical Logs
Quantitative Mineralogy from Logs, and the Interpretation

this task would be an appropriate and important duty of the JOIDES Logging Scientist. At the time of the workshop there appeared to be two main obstacles to accomplishing his task. The first, and largest, problem is the inability of any computer system other than Schlumberger's to read the field data tapes. This effectively means that processing must await the end of all logging (and must generally allow some time for the logging engineer to sleep). The second problem appeared in the proliferation of systems and software in the LDGO shipboard laboratory, a confusing situation for a new logging scientist. The panel felt strongly that LDGO should both develop the capability to read raw data tapes and also set up standardized routines for the rapid processing of at least some crucial logs (eg. gamma ray, velocity, resistivity) by the JOIDES Logging Scientist while subsequent logging runs are underway. These logs can be clearly marked as "Preliminary", but will none the less help to integrate the logging data with the rest of the individual site reports.

V. OPERATIONS

Duties of the logging scientists, processing, interpretation of data and the like are of little consequence if downhole measurements are not able to be properly obtained. Some data are lost due to operational problems that stem from the wide variety of causes which can be expected in a program as technologically challenging as deep ocean drilling. The largest single cause of failure (or success limitation) of logging programs, however, is the stability of the boreholes. The ODP representative presented a summary view of hole stability problems and the possible range of preventative or corrective measures potentially available to solve them (Table 3).

The summary of hole stability corrective measures reduces to two approaches; mud programs or casing. Mud programs, as used in the oil industry, are not generally applicable in ocean drilling

Table 3. Hole Stability Problems

I. **CHEMICAL - swelling or disintegrating hole walls due to hydrophylic clays in the formation**

* oil-based mud
* polymer mud
* salt-inhibited mud (KCl, NaCl, etc.)
* casing

II. **PHYSICAL - plastic or brittle stress relief, erosion/abrasion**

* hydrostatic equilibrium (high mud weight)
* casing

because the JOIDES Resolution does not have a riser system (ie. the drilling fluid is not recirculated, but is lost on the seafloor). The ship does not have the capacity to carry enough mud to drill for days at multiple sites without a recirculating system. The cost of most of the mud types would also be prohibitively expensive if only pumped once through the system.

Casing each hole is also not practical, due to both time and money considerations. The casing operation takes several additional days per site and incurs a high materials cost due to the need for a re-entry cone as well as the casing string itself. Casing will continue to be used in the future only for special sites where re-entry and deep logging are considered to be of the highest priority.

Borehole instability problems, due to either chemical or mechanical causes, can be diminished through other methods that are not as costly in time or money as those solutions discussed above. In the past it was customary to expend time every day during drilling to condition (clean) the borehole. This is also an accepted practice in the oilfield environment. Present calculation of coring and logging times do not include hole cleaning at deeper sites. Time taken during drilling to clean the hole has been charged to the logging program, worsening the already inadequate situation of logging time allocation at most sites. The group strongly recommended that time be included in future planning to include borehole conditioning during drilling, and that this time not be counted as part of the downhole measurements program. It was also noted that a regular program of hole conditioning will also enhance chances for coring to advance to target depths in areas where hole conditions are sub-optimal, a benefit to the entire scientific party rather than to the logging community alone. Failing this, the group suggests that time be allocated to wash a separate hole for logging, so that swelling and erosion of the borehole walls will not have many days to degrade conditions before logging commences.

Where hole conditioning is not adequate to allow tools to pass through the borehole, deployment of the Sidewall Entry Subassembly (SES) was encouraged by the panel. The SES provides a way for the logging tools to be raised and lowered along with the drill string. The tools and the drill string start at the bottom of the hole, the drill string being raised ahead of the tool string by some tens of meters. In this manner the drill string is able to clear obstructions in the borehole only minutes before the tool string passes the same point. The SES has been used successfully on several legs to collect data that otherwise would have been lost.

Deployment of the SES means a penalty in time; approximately 5-6 hrs. for the version aboard the ship in the Spring of 1989. This time has also been generally charged to the logging program. It was felt that, at least where bad hole conditions might be expected, that some additional time should be allocated to the logging program to accommodate installation of the SES in the drill string without losing time available for logging surveys.

The current version of the SES aboard the Resolution has several drawbacks. If the pipe becomes stuck in the hole during logging operations using the SES, there is no way to retrieve the logging string before severing the end of the drill pipe. A $100,000 to $200,00 string of tools would be lost in that eventuality. Deployment of the SES requires dismantling of large areas of the drill floor. Insertion of tool strings into the pipe is cumbersome and several of the activities associated with the task are dangerous to the tool string and/or the cable and cable head.

The problems with the SES are being addressed in a new design which should be ready in the Winter of 1989-90. Once the new SES is aboard, the panel felt that it should be included in logging all but the most perfect of holes. The new design will take less time to install because it will allow for the insertion and withdrawal of toolstrings while the SES is in the line. It will also allow tools to be retrieved from stuck pipe. The group strongly urged that acquisition of the new SES be a highest priority item for LDGO.

Systems maintenance and repair, both mechanical and electronic, has suffered somewhat due to the special position of the logging group vis-a-vis ODP and SEDCO. The logging group has largely depended on the goodwill of ODP technical personnel to assist in underway repair of electronic equipment. Much the same was true in the mechanical field, although LDGO and SEDCO have agreed to share a mechanic. Panel members recommended that a similar time-sharing arrangement be made with ODP for an electronics technician. There was some concern that shared individuals might only work for the logging group when necessary, rather than as an integral part of their position. In both cases a regular schedule of maintenance for all equipment would be both desirable and would also keep the technical people involved in the logging systems on a continuous basis.

VI. DATA HANDLING

The problem of timely dissemination of logging data to the rest of the scientific crew (while site reports are still being written) has been discussed above. Other areas of data handling can also be improved, particularly in the realm of the integration of logging and core data. Two recommendations were particularly directed in this direction. Due to core recovery problems at many sites, the panel suggested that the shipboard whole core scanning facility be extended to include a natural gamma-ray spectrometer to duplicate the data collected by the downhole gamma-ray sonde. This is seen as an excellent way to correlate partial core recovery to logged intervals as well as provide interesting detail at a much finer scale than provided by the logs. For full core, induction resistivity would also be useful, both for correlation and finer detail in measurements.

A second area which could improve data integration would be a method to merge wireline logging data with core barrel data. The drill ship has the graphics capabilities to computerize core descriptions in virtually real time. A data base of core description would be a natural adjunct to logging data, and in fact this integration is being done presently on an ad hoc basis during most legs. The panel felt that implementation of a core barrel database should be given a high priority by ODP. The scientists also requested that ODP provide a list of the software available aboard the drillship to participants before cruises.

Finally, the group thought that the post-cruise archiving and interpretation of logging data would be enhanced substantially by effective integration with core data. This is an area fraught with difficulty, as witnessed by the oil industry, but if successful the outcome is a refined calibration and accuracy estimation of well logging data. The group felt that the JOIDES logging and physical properties scientists should be encouraged to submit joint proposals for post-cruise studies to correlate core and log data.

VII. CONCLUSIONS

The JOIDES Downhole Measurements Panel has identified 1989 as "data quality year". This workshop has contributed a substantial part of that initiative. Twenty recommendations have been formulated for transmittal via JOI, Inc. to the relevant parties within the ODP framework. If these recommendations are brought to fruition, a further enhancement of log data quality should be forthcoming.

As ODP progresses, the scientific community is becoming increasingly aware of the expanded role of a sound and comprehensive program of downhole measurements in ocean drilling. There is every prospect of these expectations being fully realized as we move into the latter part of this phase of ODP and look ahead to the next.

APPENDIX I
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