Data report: Techlog training data set utilizing petrophysical data from IODP Expedition 346, Asian Monsoon[1]

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Chapter contents

Abstract

Using downhole log and core data generated during Integrated Ocean Drilling Program Expedition 346 Asian Monsoon, a new formatted training data set was produced and made available in the Scientific Ocean Drilling log database. The end users of this data set are intended to include researchers interested in utilizing Schlumberger's Techlog software package, which is the principal software utilized on both the R/V *JOIDES Resolution* and D/V *Chikyu*, to integrate and evaluate downhole log and supplementary data. To aid this purpose, International Ocean Discovery Program (IODP) standard tools and acronyms have been maintained throughout data processing. The data set is optimized to run smoothly on computers with the same minimum specifications as Schlumberger's Techlog software (quad-core processor with a base frequency of 3 GHz and 8 GB of RAM) and has optional supplementary data sets for higher specification systems.

Introduction

Well log data is a powerful geological data type that enables direct comparison between laboratory sample measurements and in situ measurements made downhole. Large volumes of publicly available well log data have been generated by the Integrated Ocean Drilling Program (IODP) and its past phases. During these programs, samples have been drilled, logged, and collected from almost every geological setting around the world's oceans (Goldberg, 1997); however, much of the data can go undiscovered and remain beyond the reach of geoscientists because of lack of knowledge that the data exist, lack of understanding of how to interpret the log data, and lack of software to use for interpretation.

To compound this problem, attaining the necessary skills to operate software packages for unpacking, analyzing, and interpreting log data can be expensive and time consuming. Although many log interpretation software providers offer software at subsidized prices, training in the operation of the software typically requires a fee. Further, after formal training is complete few opportunities exist for researchers to expand on the synthesized training schedule and its associated data. This can result in an environment with little easily accessible and appropriately formatted data from which researchers can gain experience.

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The nature of downhole data is such that the data can be seemingly inaccessible to nonexperts. This, coupled with the fact that publicly available data sets are often not clean or well organized and sometimes are unconventionally labeled, can make using downhole data an unappealing and daunting task. One example of this complexity is Schlumberger's online mnemonics list, which has >50,000 entries (Rider and Kennedy, 2011). Additional mnemonics can also be generated by modified acquisition processes and tools or by company-specific mnemonics, significantly expanding the length of this list.

In an attempt to provide a more accessible introduction to the use of downhole logging data, the Techlog training data set was developed using data acquired during Integrated Ocean Drilling Program Expedition 346.

Expedition 346, sailing in 2013, aimed to explore the climate system surrounding the marginal sea that borders the islands of Japan, the Eurasian continent, and the Korean peninsula. Primary expedition research focuses were on the following areas:

- Determining the effect of uplift of the Himalaya and Tibetan Plateau on the position of the Westerly Jet throughout the Pliocene and Pleistocene,
- Specifying timing and onset of orbital- and millennial-scale variability in the East Asian Summer Monsoon,
- Reconstructing paleoceanographic changes in productivity and bottom water circulation over the last 5 My, and
- Reconstructing the history of the Yangtze River discharge.

Although the Expedition 346 downhole logging program contributed to all expedition research aims, the primary contribution was to reconstruction of paleoceanographic changes in productivity by providing continuous data throughout the full depth of the hole.

Previous scientific drilling expeditions in the region, Ocean Drilling Program (ODP) Legs 127 (summer 1989) and 128 (fall 1989), covered a wide range of drilling targets in the marginal sea, such as volcanic massive sulfide deposits and deciphering the nature of basin extension (Tamaki, Pisciotto, Allan, et al., 1990; Ingle, Jr., Suyehiro, von Breymann, et al., 1990). Expedition 346, however, was the first expedition in the region to focus on paleoclimate systems (see the **"Expedition 346 summary"** chapter [Tada et al., 2015a]) and expand on objectives first targeted at ODP Site 798 (Ingle, Jr., Suyehiro, von Breymann, et al., 1990).

Data from Expedition 346 were chosen for the creation of a Techlog training data set because the expedition logged four of the seven drilled sites spread across a single basin with basin-wide lithofacies. High-quality data were generated for complete hole depths at all four sites, and these data were integral for achieving the Expedition 346 scientific objectives.

Intended for use with Schlumberger's Techlog software, the training data set introduces users to Schlumberger's Techlog package itself while simultaneously introducing basic downhole log data quality assurance/quality control and some of the ways that Techlog can be used to integrate multiple data sets and interrogate them together. The target end users are researchers who are less familiar with downhole log data sets; however, the data set should be useful to anyone who is unfamiliar with IODP log data acronyms and processing standards.

The data set was created to encourage an interdisciplinary approach by incorporating data from multiple methods of shipboard data acquisition, including downhole log data, core physical property data, discrete sample data, and core images.

The data set is designed to function without any latency on computers with the following minimum specifications:

- Intel Core i5 processor or equivalent (quad-core processor with a base frequency of 3 GHz), and
- 8 GB of RAM.

These are the same minimum system requirements for Schlumberger's Techlog version 2017.2 and are lower than the recommended Techlog system requirement of 16 GB of RAM.

Methods and materials

All data incorporated into the data set originate from the offshore phase of Expedition 346 (shipboard data). Expedition 346 logged four sites in the marginal sea:

- Site U1423B: 249 m deep hole at 41°41.95′N, 139°4.98′E and 1785 meters below sea level (mbsl);
- Site U1425B: 407 m deep hole at 39°29.44′N, 134°26.55′E and 1909 mbsl;
- Site U1427A: 548 m deep hole at 35°57.92′N, 134°26.06′E and 330 mbsl; and
- Site U1430B; 275 m deep hole at 37°54.16′N, 131°32.25′E and 1072 mbsl.

Data originate from multiple sources, which are included in the IODP standard measurements list (**http://www.iodp.org/jr-facility-policies-procedures-guidelines/117-jr-measurements-final/file**).

Downhole log data

As with most IODP expeditions, Expedition 346 shipboard data include a suite of downhole logs generated by two tool strings. The first tool string used in each hole was the Paleo combination (paleo combo), a variation of the triple combination (triple combo) tool string on which the porosity tool (Accelerator Porosity Sonde [APS]) was replaced with the Magnetic Susceptibility Sonde (MSS). The second tool string was the Formation MicroScanner (FMS)-sonic.

Together, these tool strings generate a suite of downhole logs that include information on formation resistivity, natural gamma radiation (NGR), density, magnetic susceptibility, sonic velocity, and borehole diameter (Table **T1**). The FMS also produces electrical resistivity images of the borehole wall at a 5 mm resolution. For more information, see **"Downhole measurements"** in the "Methods" chapter (Tada et al., 2015b).

Expedition logging data processed by the Lamont-Doherty Earth Observatory Borehole Research Group were downloaded from the Scientific Ocean Drilling log database (**http://mlp.ldeo.columbia.edu/logdb/hole/?path=iodp-usio/exp346/U1423B/**). Processed data are already principally depth matched between logging runs and corrected to seafloor depth.

Only a single instance of each variable was kept, and many accessory variables were removed to simplify the data set and enhance accessibility. This gives a streamlined data set that contains only the most commonly used log variables. The chosen variables universally originate from primary logging runs for both the FMS-sonic and paleo combo tool strings.

FMS images were recreated and saved as borehole image arrays in the Techlog format with the following image processing parameters:

- 20 m window size for dynamic images,
- Global button processing method; and
- Depth-shifted FMS images to match calculated true formation resistivity.

A bit-size variable was also interpolated from unprocessed original data and modified to match info in the *Proceedings* volume (11⁷⁄₁₆ inches [~11.4375 cm] instead of 9¾ and 11¾ inches recorded in the original DLIS files).

Core data

Even with high-quality downhole log data, recovering core material for groundtruthing and sampling is standard for all IODP expeditions. In the case of Expedition 346, recovering core from the marginal sea was also an essential target to complete to achieve the scientific objectives. Expedition 346 is an exception, however, in volume of core; at 6135.3 m, more core was recovered than during any other single IODP expedition at the time. This significant recovery enables the core and discrete sample physical property data sets to cover almost the complete depth range of each hole.

Downhole log and core data are complementary because core samples provide material for classic sedimentary, petrological, and structural analyses and log data provide measurements that are continuous with depth and under in situ conditions. Further, core and log analyses measure over different scales and capture different structural and petrological controls. For example, because of its length, the Dipole Sonic Imager acoustic velocity sonde on the FMS-sonic tool string (Table **T1**) has an approximate vertical resolution of 107 cm when sampling at 15 cm intervals. Core-based acoustic velocity measurements can be conducted at the centimeter scale to prioritize matrix characterization over structure. Just as unique data can be acquired downhole, core measurements can also include data that are not always possible to obtain in a downhole environment, such as color spectroscopy. This integration of multiple data types is key to understanding the power of the interdisciplinary data sets recovered by IODP.

The full suite of IODP standard measurements was gathered for the total depth cored at each site. However, for the purposes of this training data set, only a few specific discrete sample data types were included: bulk density, grain density, and porosity. All three data types are recovered from moisture and density (MAD) measurements collected using the helium pycnometry method outlined by Blum (1997). Here, wet mass, dry mass, and dry volume are measured on ~10 cm^3 push-core samples to calculate water content and porosity.

When importing IODP core data into a log data set, depth values can be taken as either core depth below seafloor, Method A (CSF-A) or Method B (CSF-B). CSF-A represents distance below seafloor calculated from drilling depth, core depth, and measurement location in the core. CSF-B is identical except that where core recovery is >100%, a compression algorithm is applied to account for core expansion caused by decompression.

During Expedition 346, MAD samples were taken at regular intervals of 1 or 2 per core, usually from Sections 2 and 5 (see **"Physical properties"** in the "Methods" chapter [Tada et al., 2015b]), providing an average spatial resolution downhole of 1 point per 4.75 m. Discrete samples were not taken for MAD analysis from all holes at a site because of prior sampling for a particular depth/stratigraphic range in a previous hole at that site, assuming that stratigraphy should not vary significantly with 15 m of lateral shift. Where core data logged in a hole at a site were unavailable for this reason, data were loaded into the training data set from the nearest adjacent hole at the same site. On occasion, discrete sample data from two holes were combined to generate a complete data set for the depth interval. This was done for Hole U1423B, where samples for the uppermost 205 m were taken from Hole U1423A (15 m northward), and Hole U1430B, where all samples were taken from Hole U1430A (15 m northward).

Expedition 346 core data were also gathered through the use of "track" core logging systems, which nondestructively acquire data from both whole-round and split-core sections. Gamma ray attenuation (GRA) bulk density, magnetic susceptibility, and NGR data were acquired in this way and are included in the training data set.

Spatial resolution for GRA density and magnetic susceptibility is one measurement every 2, 2.5, or 5 cm along whole-round cores (section dependent), whereas NGR data were acquired at a resolution of 8 measurements per 150 cm core section, generating a mean downhole measurement resolution of 18.75 cm. Because of the measurement technique, track data have a consistent sampling interval downcore. However, data still need to be imported as point data with an inconsistent sampling rate because cleaning the data removes bad measurement points, inconsistent section lengths produce odd numbers, and incomplete core recovery and expanded recovery shifts the true measurement point depths.

The final form of core data included in the training data set comes from core images. Line scan images were taken of all archive-half core sections, which is standard procedure during IODP expeditions. Because of the high resolution of these images and associated high-RAM requirements, only a 50 m interval was taken in Hole U1427A (379.1–430.8 m CSF-A; Cores 58H through 68H). In addition, images were compressed to aid data set functionality on underpowered systems. Images have been renamed with top and bottom depths (CSF-B) in the file name to allow Techlog to assign them to the correct interval.

Additional data sources

Expedition data are extensive but not exhaustive. Additional data were created to supplement the shipboard data and ease the interpretation process. Data were created in the form of additional log variables written into the DLIS files, including bad hole flags calculated from bit size and bulk density correction, a core recovery flag from the IODP section recovery reports (CSF-B), and a shale volume calculation derived from the NGR log. Additionally, an interval.txt variable detailing basin-wide lithostratigraphy identified from shipboard data and duplicate logging runs for training with Techlog-specific tools were created.

Bad hole flags were created to help identify areas where data quality and interpretation may be weakened. Two bad hole variables were created, one from caliper tool diameter and one from bulk density correction. Caliper-based borehole quality flags are generated based on the principle that data quality is reduced where the Hostile Environment Litho-Density Sonde (HLDS) caliper arm reads a hole diameter > 14 inches (35.5 cm) because of an increased proportion of drilling mud (as opposed to formation) being measured. This is key for the density tool (HLDS), which is an eccentralized tool that requires good contact of its pad with the borehole wall (Schlumberger, 2015). Bulk density correction borehole quality flags are generated using density variance between the near and far detectors on the HLDS. A correction is applied to the signal to calculate true formation density. This correction is automated in modern tools and is calculated empirically for different drilling-mud types. The following bulk density corrections are used to create bad hole flags:

- 0 = bulk density correction_min ≤ bulk density correction ≤ bulk density correction_max,
- 0 = –0.1 ≤ bulk density correction ≤ 0.1, and
- 1 = any other outcome.

Core recovery flags written into the DLIS files were generated using section summaries from the IODP Laboratory Information Management Information (LIMS) database. Section reports were collated, and where the section top depth (CSF-B) did not match the bottom depth of the preceding section, a gap in recovery was assumed. Section depth values were collated into simplified CSV files and imported into the DLIS as a flag variable with the same sampling rate as the depth reference: 1 = core, 0 = no core recovery. Section reports provided higher resolution flag variables than core reports (1.5 m instead of ~9 m) and more accurately account for gaps in discrete sample and physical property track data sets.

Shale volume calculations (VSH variables) were generated from NGR logs acquired by the Enhanced Digital Telemetry Cartridge using the following calculation:

$$GR_{index} = (GR - GR_{matrix})/(GR_{shale} - GR_{matrix}),$$

where

GR = gamma ray log (API),
GR_{matrix} = gamma ray log reading 100% matrix rock, and
GR_{shale} = gamma ray log reading 100% shale.

The linear method was applied (VSH = GR_{index}), and VSH was calculated using the same default parameters for all holes: GR_{matrix} = 10 API and GR_{shale} = 100 API.

Additional stratigraphy data comprises a TXT file that plots expedition lithostratigraphy identified from core as Techlog intervals (Table T2) with top depths and bottom depths for each zone in the borehole.

Additional logging runs were duplicated for training with Techlog's well-identification solver program. The duplicated logging runs were intentionally misnamed in the LAS header so that they can be assigned correctly as a showcase for the software.

Results

Acquired logging data are presented in a series of data files determined by tool string or sonde, which is standard during all IODP expeditions, and by sampling rate inside Techlog. In the output training data set (Figures F1, F2, F3, F4), data from all sources were compiled and exported in single hole-specific DLIS files in which variables are sorted by a simplified suite of sampling rates. Supplementary data files were separated, and all data were depth matched as best as resolution allowed after down-sampling.

Two primary data sets were created for each hole in a single DLIS file. Both were named "Datafull" to suggest a full suite of log data, one with the suffix "Standard" and another with the suffix "High Res" to indicate the differing sampling rates. As a consequence of this format, some variables were down-sampled from their original sampling rate.

Down-sampled data include the highest resolution outputs from the HLDS (from 0.0254 to 0.0508 m) and magnetic susceptibility data (from 0.0254 to 0.0508 m). A resolution of 0.0508 m was chosen to match the resistivity data resolution. Data set variable content was also modified from the standard IODP processed data set variable suite to aid understanding. A complete list of the variables is in Table T3. Further, data sets were trimmed to new top and bottom depths (Table T4).

Supplementary data files

To make the Expedition 346 training data set a more flexible tool, some supplementary data were separated out from the Datafull DLIS files in a series of file types. Additional data sets comprise

- FMS image data sets in separate DLIS files,
- Survey data sets with data for hole inclination, deviation, and azimuth,
- Physical property track data CSV files containing point data for GRA bulk density, magnetic susceptibility, and NGR,
- Text files detailing stratigraphy, and,
- GIF files of core images.

Supplementary data set variables are detailed in Table T5. Training data set file structure was organized by file type to ease the import process (see the "Appendix").

FMS image data sets were kept separate from the Datafull DLIS files because these images can be considered a less standard data type. In addition, FMS logs contain large volumes of data. Each oriented image consists of 77 variables concatenated, which increases the DLIS file size and reduces usability on underpowered systems. Finally, by separating images from standard data, users can run custom scripts during import.

FMS images were created for full measured intervals in all holes and a duplicated short interval in Hole U1427A. This compressed interval image is designed for operation on underpowered systems and covers the same interval as the GIF images (379.1–430.8 m). In addition to the borehole image array, FMS image DLIS files contain associated tool parameters for dip picking in Techlog. The complete variable list is in Table T5. Images were depth matched to RT_HRLT in the Datafull DLIS data sets.

Further supplementary data sets have been compiled in the form of mimic survey data LAS files. Saved separately from the Datafull DLIS files, survey data are intended to resemble standard industry data format. Survey data comprise azimuth and inclination data exported from the General Purpose Inclinometry Tool on the FMS-sonic tool string. These variables cover the entire interval of the drilled hole and were trimmed to the same depths as the Datafull DLIS files.

Track data CSV files containing GRA bulk density, magnetic susceptibility, and NGR data have been depth matched to Datafull log data sets. Occasionally, these physical property data are not aligned with core recovery flags because the track data originate from a different hole than the core flag. See "Core data" for details of where this may occur.

Intentional errors were incorporated into the data set, which is common in training data sets. One such example is a depth mismatch between the Datafull Standard and the Datafull High Res data sets in Hole U1430B. The high-resolution data set was linearly shifted 4 m downhole. Another example is the repetition of data in "RUN_1, 2, 3, 4" LAS files designed for use in well-renaming exercises.

Conclusion

Downhole log and core data recovered during IODP Expedition 346 Asian Monsoon were formatted into a simplified, training-oriented arrangement and made available from the Scientific Ocean Drilling log database (**http://mlp.ldeo.columbia.edu/logdb/hole/?path=iodp-usio/exp346/U1423B/**). Although not exhaustive, the training data set provides a good representation of standard log data while maintaining IODP acronyms, common data types, and treatment.

Details of the contained variables are provided above and summarized in Tables **T3** and **T5**. Further variable treatment and processing over and above standard processing is outlined and the final data set format is summarized. Multiple data formats are utilized (DLIS, LAS, CSV, TXT, and GIF), and details on file structure are given.

Supplementary data sets were created to increase data flexibility and demonstrate the power of integration when investigating IODP data.

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Appendix

The training data set is organized by file type in the following file structure.

346 Training Dataset
- 01 DLIS
  - U1423B.dlis
  - U1425B.dlis
  - U1427A.dlis
  - U1427A_FMS_Interval.dlis
  - U1430B.dlis
- 02 LAS
  - U1423B.las
  - U1425B.las
  - U1427A.las
  - U1430B.las
- 03 TXT
  - ZONES.txt
- 04 CSV
  - U1423B.csv
  - U1425B.csv
  - U1427A.csv
  - U1430B.csv
- 05 Core images GIF
  - U1427A
    - DayLight
      - 346-u1427a-58h-1-379.100-379.822.gif
      - 346-u1427a-58h-2-379.822-380.985.gif
      - 346-u1427a-58h-3-380.985-382.189.gif
      - 346-u1427a-58h-4-382.189-383.111.gif
      - 346-u1427a-58h-5-383.111-383.659.gif
      - 346-u1427a-58h-cc-383.659-383.800.gif
      - 346-u1427a-59h-1-383.800-385.090.gif
      - 346-u1427a-59h-2-385.090-385.890.gif
      - 346-u1427a-59h-3-385.890-386.700.gif
      - 346-u1427a-60h-1-388.500-389.760.gif
      - 346-u1427a-60h-2-389.760-390.965.gif
      - 346-u1427a-60h-3-390.965-392.308.gif
      - 346-u1427a-60h-4-392.308-392.989.gif
      - 346-u1427a-60h-cc-392.989-393.200.gif
      - 346-u1427a-61h-1-393.200-394.610.gif
      - 346-u1427a-61h-2-394.610-396.029.gif
      - 346-u1427a-61h-3-396.029-397.120.gif
      - 346-u1427a-61h-4-397.120-397.787.gif
      - 346-u1427a-61h-cc-397.787-397.900.gif
      - 346-u1427a-62h-1-397.900-398.781.gif
      - 346-u1427a-62h-2-389.781-399.719.gif
      - 346-u1427a-62h-3-399.719-400.810.gif
      - 346-u1427a-62h-4-400.810-401.681.gif
      - 346-u1427a-62h-5-401.681-402.466.gif
      - 346-u1427a-62h-cc-402.466-402.600.gif
      - 346-u1427a-63h-1-402.600-403.000.gif
      - 346-u1427a-63h-2-403.000-404.066.gif
      - 346-u1427a-63h-3-404.066-405.408.gif
      - 346-u1427a-63h-4-405.408-406.421.gif
      - 346-u1427a-63h-5-406.421-407.114.gif
      - 346-u1427a-63h-cc-407.114-407.300.gif
      - 346-u1427a-64h-1-407.300-407.964.gif
      - 346-u1427a-64h-2-407.964-409.170.gif
      - 346-u1427a-64h-3-409.170-410.419.gif
      - 346-u1427a-64h-4-410.419-411.135.gif
      - 346-u1427a-64h-5-411.135-411.790.gif
      - 346-u1427a-64h-cc-411.790-412.000.gif
      - 346-u1427a-65h-1-412.000-413.347.gif
      - 346-u1427a-65h-2-413.347-414.740.gif
      - 346-u1427a-65h-3-414.740-415.864.gif
      - 346-u1427a-65h-4-415.864-416.533.gif
      - 346-u1427a-65h-cc-416.533-416.700.gif
      - 346-u1427a-66h-1-416.700-417.880.gif
      - 346-u1427a-66h-2-417.880-419.130.gif
      - 346-u1427a-66h-3-419.130-420.230.gif
      - 346-u1427a-66h-4-420.230-420.830.gif
      - 346-u1427a-66h-cc-420.830-421.270.gif
      - 346-u1427a-67h-1-421.400-421.917.gif
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      - 346-u1427a-67h-4-424.343-425.306.gif
      - 346-u1427a-67h-5-425.306-425.921.gif
      - 346-u1427a-67h-cc-425.921-426.100.gif
      - 346-u1427a-68h-1-426.100-426.240.gif
      - 346-u1427a-68h-2-426.240-426.782.gif
      - 346-u1427a-68h-3-426.782-427.913.gif
      - 346-u1427a-68h-4-427.913-429.099.gif
      - 346-u1427a-68h-5-429.099-430.024.gif
      - 346-u1427a-68h-6-430.024-430.632.gif
      - 346-u1427a-68h-cc-430.632-430.800.gif

- 06 Exercises
  - 01 Import Exercise
    - 01 Well identification solver
      - RUN_1.las
      - RUN_2.las
      - RUN_3.las
      - RUN_4.las
  - 02 Full FMS Images
      - U1423B_FMS.dlis
      - U1425B_FMS.dlis
      - U1427A_FMS.dlis
      - U1430B_FMS.dlis

Figure F1. Hole U1423B log data included in the Techlog training data set. See Table T3 for acronym definitions.

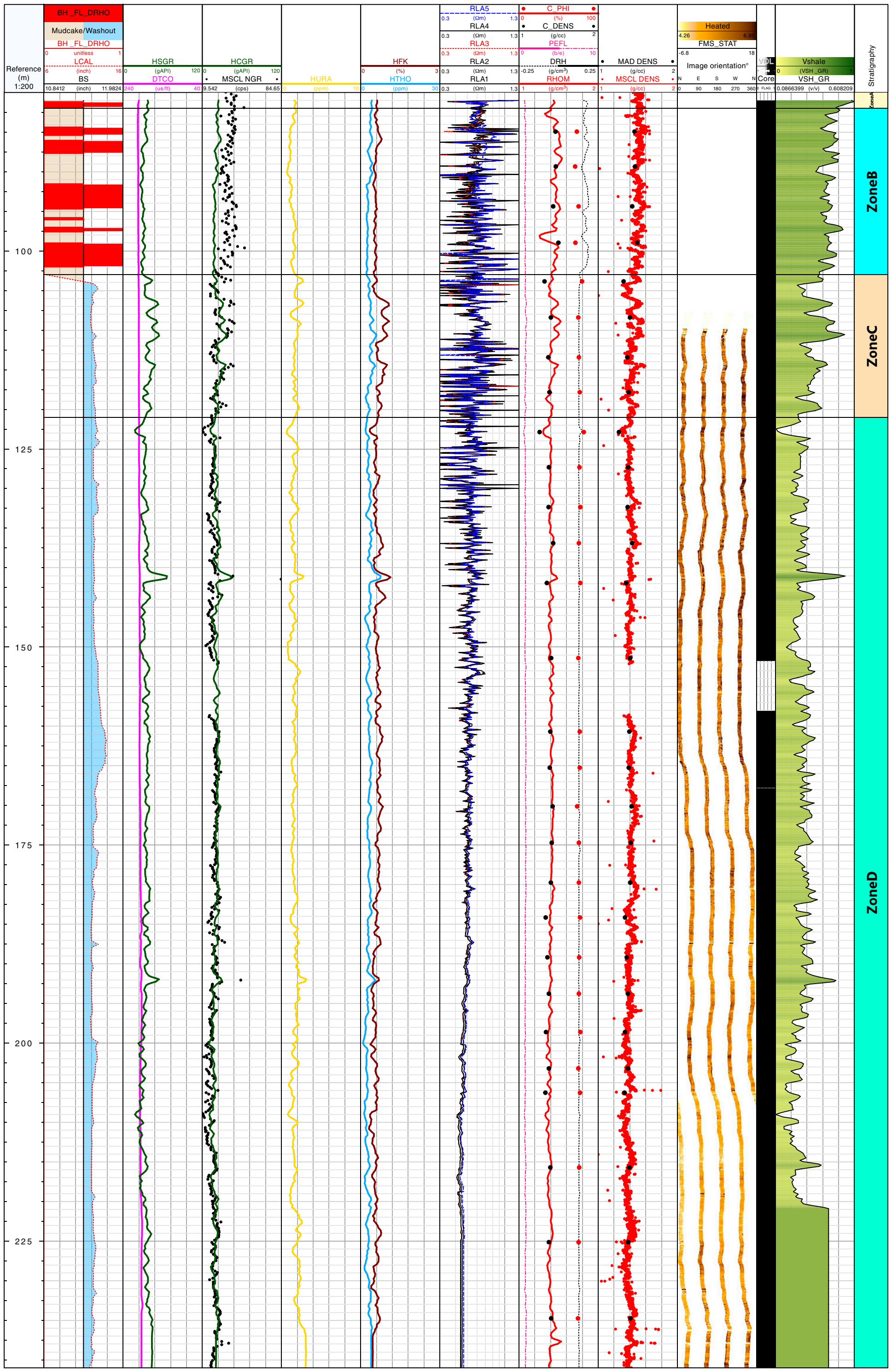

Figure F2. Hole U1425B log data included in the Techlog training data set. See Table T3 for acronym definitions.

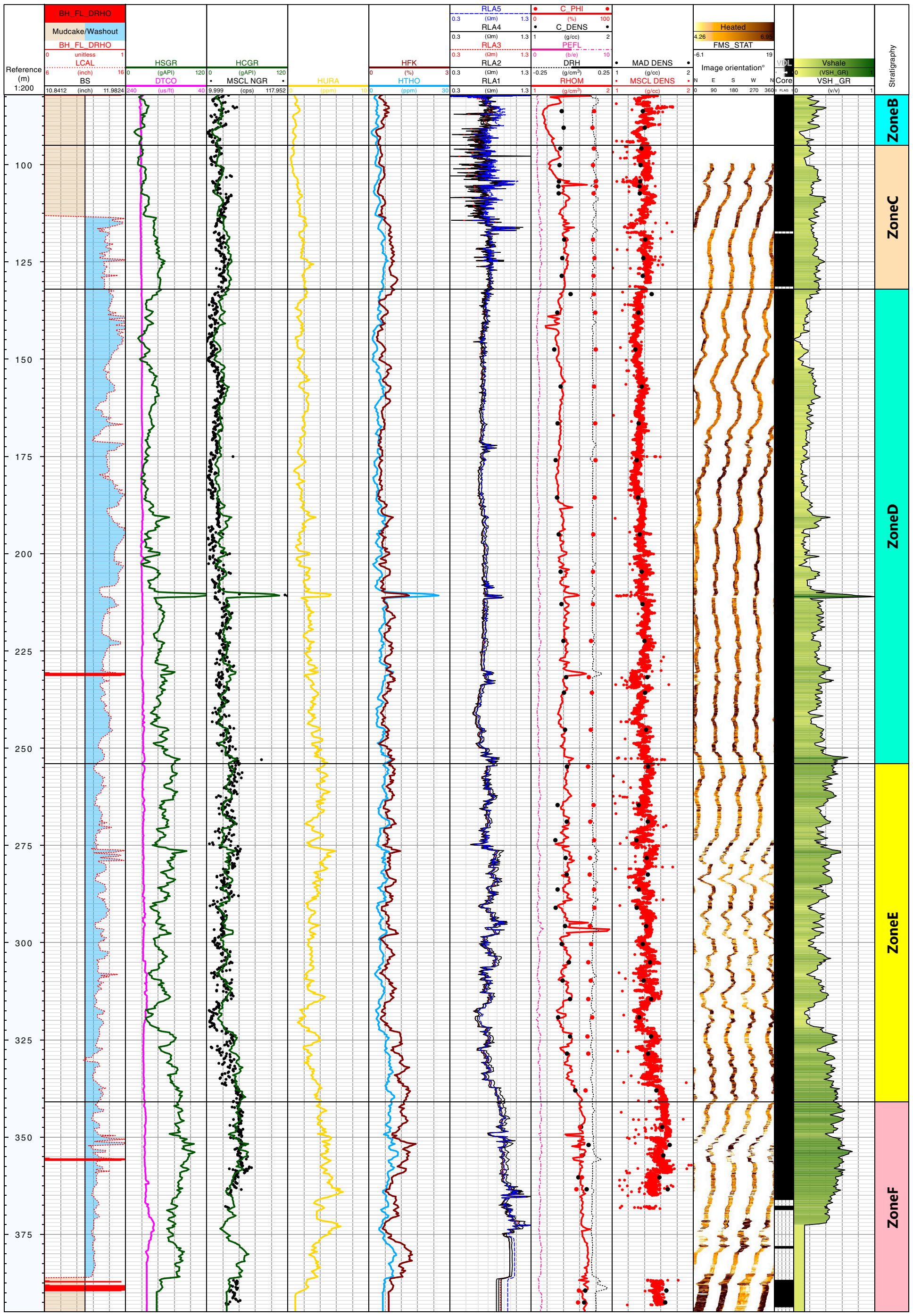

Figure F3. Hole U1427A log data included in the Techlog training data set. See Table T3 for acronym definitions.

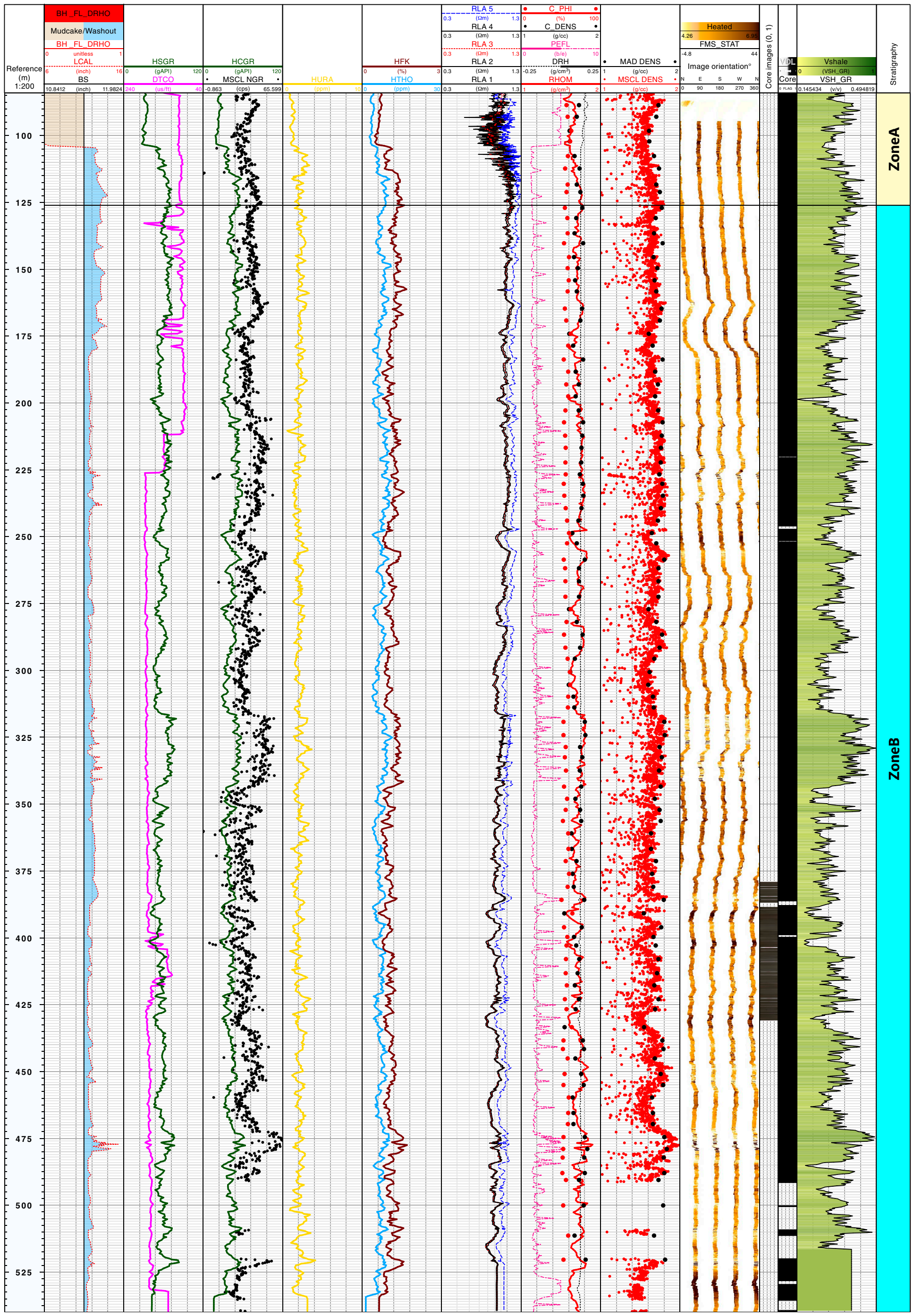

Figure F4. Hole U1430B log data included in the Techlog training data set. See Table **T3** for acronym definitions.

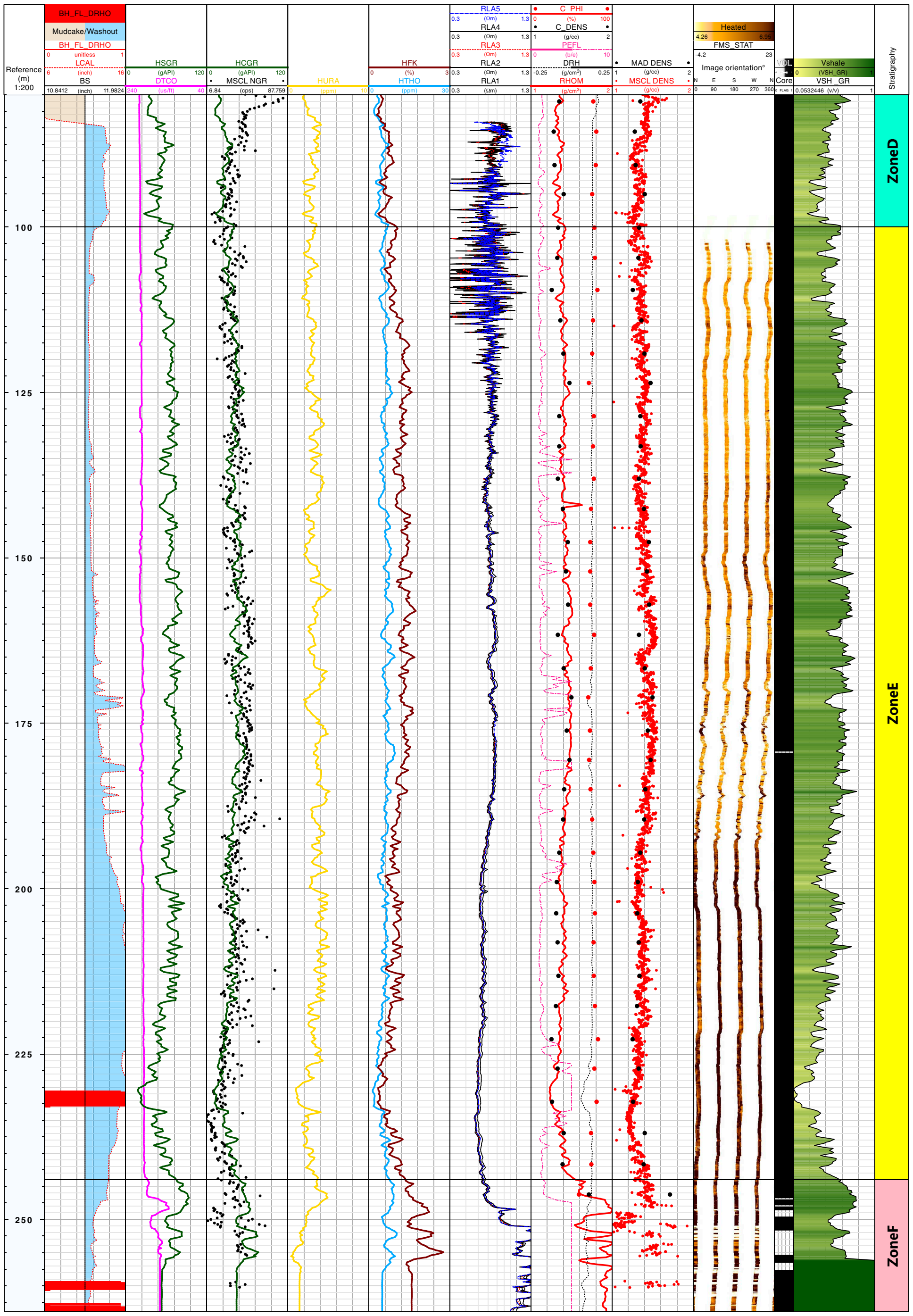

Table T1. Downhole tool strings used during Expedition 346.

Tool string	Tool	Definition	Primary outputs
Paleo combo	EDTC	Enhanced Digital Telemetry Cartridge	Total gamma Environmentally corrected gamma ray (for borehole diameter) Borehole fluid temperature
	HNGS	Hostile Environment Natural Gamma Ray Sonde	Total gamma Computed gamma (uranium concentration removed) Uranium concentration Thorium concentration Potassium concentration
	HLDS	Hostile Environment Litho-Density Sonde	Density Photoelectric factor Caliper
	HRLA	High-Resolution Laterolog Array Tool	Formation electrical resistivity at 5 depths of investigation Computed "true formation resistivity" Drilling fluid electrical resistivity
	MSS	Magnetic Susceptibility Sonde	Magnetic susceptibility
FMS-sonic	EDTC	Enhanced Digital Telemetry Cartridge	Total gamma Environmentally corrected gamma ray (for borehole diameter) Borehole fluid temperature
	HNGS	Hostile Environment Natural Gamma Ray Sonde	Total gamma Computed gamma (uranium concentration removed) Uranium concentration Thorium concentration Potassium concentration
	DSI	Dipole Sonic Imager	Compressional slowness
	GPIT	General Purpose Inclinometry Tool	Hole azimuth Hole deviation
	FMS	Formation MicroScanner	Resistivity images

Table T2. Lithostratigraphic layers identified offshore during Expedition 346 and the corresponding Techlog zone in the TXT supplementary file.

Techlog zone	Lithostratigraphic layer	Key lithologies	Primary structures
A	1a	Clayey silt Silty clay Silty sand Nannofossil-rich clayey silt Biosiliceous-rich clayey silt Nannofossil ooze	Meter- to several tens of meters–scale alternations of biogenic component–rich clayey silt and biogenic component–poor clayey silt.
B	1b	Clayey silt Silty clay Silt Nannofossil-rich clayey silt Biosiliceous-rich clayey silt Nannofossil ooze	Zone B is distinguished from Zone A by the lack of dark color intervals and the occurrence of laminated sediment. Lithology is similar to that of Zone A and is characterized by the same meter-scale alternations in biogenic component abundance.
C	2a	Diatom-bearing and diatom-rich clay Clay	This subunit is considered transitional from Zone B to the underlying Zone D, which is defined by the consistent appearance of diatom ooze. In general, sediments in this unit are heavily bioturbated, leading to poor preservation of original sedimentary structures.
D	2b	Dominated by diatom ooze (typically >70% (and as much as 95%) of the sediment) Limited clay intervals	Moderate to heavy bioturbation and distinctive mottling are also displayed in some sections. Tephra layers (vitric and scoriaceous) and occasional individual pumice stones are a minor but common component.
E	3a	Diatomaceous ooze Diatom-rich silty clay Diatom-bearing silty clay	Alternating layers that show decimeter- to meter-scale cycles of diatom ooze (relatively clay poor) and diatom-rich silty clay (relatively fewer diatoms and more clay).
F	3b	Well lithified gray siliceous claystone	Occasional parallel laminations, burrows, and carbonate concretions appear as layers and nodules.

Table T3. Variables and their acronyms in each of the Datafull data sets contained in the simplified Techlog training data set DLIS files.

Standard		High resolution	
Variable	Description	Variable	Description
MD	Measured depth (reference)	MD	Measured depth (reference)
BAD_HOLE	Bad hole flag (LCAL > 14 inches)	EHGR_EDTC	High-resolution corrected gamma ray
BH_FL_DRHO	Bad hole flag calculated from bulk density correction	HBDC	High-resolution bulk density correction
BS	Bit size	HGR_EDTC	High-resolution gamma ray
C_DENS	Density from MAD measurements	HROM	High-resolution corrected bulk density
C_GDENS	Grain density from MAD measurements	MSSLSUS_LDEO	Low-resolution magnetic susceptibility
C_PHI	Porosity from MAD measurements	RLA1	Apparent resistivity from computed focusing Mode 1 (shallow)
CORE	Core recovery flag	RLA2	Apparent resistivity from computed focusing Mode 2
CS	Cable speed	RLA3	Apparent resistivity from computed focusing Mode 3 (medium)
DRH	Bulk density correction	RLA4	Apparent resistivity from computed focusing Mode 4
DT1	DSI shear slowness, lower dipole (ms/ft)	RLA5	Apparent resistivity from computed focusing Mode 5 (deep)
DT2	DSI shear slowness, upper dipole (ms/ft)	RM_HRLT	HRLT computed mud resistivity
DTCO	Sonic compressional delta time (computed downhole; ms/ft)	RT_HRLT	HRLT true formation resistivity
DTSM	Delta time shear (ms/ft)	TIME	Time index
ECGR_EDTC	Environmentally corrected gamma ray		
ETIM	Elapsed logging time		
GR_EDTC	Gamma ray		
HCGR	HNGS computed gamma ray		
HFK	HNGS formation potassium concentration		
HSGR	HNGS standard gamma ray		
HTHO	HNGS formation thorium concentration		
HURA	HNGS formation uranium concentration		
ITT	Integrated transit time		
LCAL	Density caliper		
MTEM	Mud temperature		
PEFL	Long-spaced corrected photoelectric factor		
PEFS	Short-spaced corrected photoelectric factor		
RHOM	Bulk density		
TENS	Cable tension		
TIME	Time index		
VELP	Compressional velocity (computed from waveforms; km/s)		
VELS	Shear velocity (computed from waveforms; km/s)		
VSH_GR	Shale volume calculated from gamma ray		

LCAL = caliper, DSI = Dipole Sonic Imager, MAD = moisture and density, HNGS= Hostile Environment Natural Gamma Ray Sonde, HRLT = High-Resolution Laterolog Tool.

Table T4. Data set top and bottom depths.

Hole	Data set	Top depth (mbsf)	Bottom depth (mbsf)
U1423B	Standard	81	241.02
	High resolution	81	241.02
U1425B	Standard	82	395.03
	High resolution	82	394.98
U1427A	Standard	84	539.98
	High resolution	84	539.98
U1430B	Standard	80	263.95
	High resolution	80	264.00

Table T5. Supplementary data set variables and descriptions.

Variable	Description
FMS_IMG	
TDEP	Measured depth (reference)
FMS_DYN	Dynamically normalized Formation MicroScanner image
FMS_STAT	Statically normalized Formation MicroScanner image
ASSOC_CAL	Associated caliper
C1	Caliper 1
C2	Caliper 2
DEVI	Deviation
EV	Emex voltage
HAZI	Hole azimuth
P1AZ	Pad 1 azimuth
RB	Relative bearing
SDEV	Sonde deviation
Physical properties track	
MD	Measured depth (reference)
C_DENS	GRA density measured by track* (g/cm^3)
MagSus	Magnetic susceptibility measured by track* (SI; unitless)
NGR	Natural gamma radiation measured by track* (counts/s)
Survey	
TDEP	Measured depth (reference)
DEVI	GPIT hole deviation (°)
HAZI	GPIT hole azimuth (°)

* = track measurements made in laboratory. GRA = gamma ray attenuation, GPIT = General Purpose Inclination Tool.