IODP Expedition 319 Logging Operations and Data Processing Report

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Hole C0009A Operation Summary

Hole: C0009A

Location: Nankai Trough (NW Pacific Ocean)

Latitude: 33° 27.4704'N Longitude: 136° 32.1489'E

Logging Date: July 12-13 (Runs 1, 2), 14-15 (Run 3), 24-25 (Runs 4, 5)

Seafloor depth: 2082.3 mBRF (driller's), 2081.1 mWSF (logger's)

Total penetration: 1603.7 mDSF (3686 mDRF)

Total core recovered: 74.7 m

Lithologies: Silty mud and mudstone with rare sand and volcanic ash interbeds, abundant wood/lignite fragments

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Logging Operations Summary

For the operational purposes Hole C0009A was drilled with MWD which was combined with APWD and vertical drilling tool PowerDrive for some sections (**Table 1, Figure 2**). Drilling for the two different zones, MWD measurements with annular pressure while drilling were used to the 2795 m DRF (712.7 m DSF) between 24-25 May, 2009 for the 20" casing, and only MWD measurements were made for lower section to the depth of 3592 m DRF (1509.7 m DSF) between 28 July-2 June for the 12-1/4" riser hole. Five wireline runs were made three runs after riser drilling and coring, two runs (junk basket and VSP runs) after the hole was cased. A walk-away VSP experiment was carried out after hole was cased and cemented, and then followed by the zero-offset VSP run (**Figure 1**).

Upon completion of drilling with 12-1/4 inch bit to the depth of 3686 m DRF (1603.7 m DSF) and a wiper trip, the first wireline logging tools were rigged at 2230 hr on 7 July 2009. The passive heave compensator (see "Methods" chapter in Expedition Report) was set up at 0100 hr on 8 July 2009. This was the first time the passive heave compensator was used instead of the active heave compensator, which is typically used for riserless logging operations. Set-up and use of this system throughout wireline logging operation was smooth.

The first wireline logging run began with the EMS-HRLA-PEX-GR toolstring (23.6 m length) (**Figure 3**). Density/porosity, gamma ray, calipers, laterolog resistivities, and mud properties were measured during this run. The toolstring could not pass beyond 1585.9 m wireline log matched depth below seafloor (WMSF) after several attempts and hence the hole was logged from that depth to the casing shoe (703.9 mWMSF) missing 8 m of cored zone at the bottom of hole. A repeat section of 101.5 m was logged from the bottom to 1493.9m WMSF. The main log covers an interval between 703.9 m and 1585.9 m WMSF. FMI, sonic scanner, and HNGC (spectral gamma) measurements were made in second wireline run. During the run, trouble at the oscillator unit of the wireline unit caused delay between 1500 and 1615 mWMSF, and the tool string could not be lowered deeper than 1581.1 mWMSF. After several failed attempts, this run was logged from that depth to the 20 inch casing shoe, and a repeat section was logged between 849.5 and 763.9 mWMSF.

The third wireline run consisted of the modular formation dynamic tester (MDT) for formation stress, pore-pressure, and permeability measurement, with gamma ray for precise depth targeting of measurement intervals. Data collected from the first two logging runs were used to select the locations of the MDT tests.

Junk basket (8-1/4" gauge ring) run was made after casing and followed by walkaway, circular and zero offset VSPs with VSI-16.

Failures during logging operations

Several failures on logging tools and its support instruments happened during the logging operations. Details can be found in the Wireline End of Well Report (Schlumberger).

Operation	Data	Depth (m LSF)	Runs
Jet-in 36" conductor pipe		~54.5	
Riserless 26" drilling, Leak-Off-Test	MWD-APWD-GR	54.5-712.7	Run 1A
Leak-Off-Test		703.7~715.7	
Riser drilling (12-1/4")	MWD-GR	712.7~1509.7	Run 1B
Riser drilling & coring	MWD-GR	1509.7~1593.9	Run 1C
Hole opening to 12-1/4"	MWD-GR	~1603.7	Run 1D
Wireline logging run 1	EMS-HRLA-TLD-CNL-GR-SP	692.3~1589.1	Run 2
Repeat	EMS-HRLA-TLD-CNL-GR-SP	1489.5~1590.4	
Wireline logging run 2	FMI-HNGS-EMS-MSIP-PPC-GR	674.7~1581.1	Run 3
Repeat	FMI-HNGS-EMS-MSIP-PPC-GR	763.7~818.9	
Wireline logging run 3	MDT-GR	14 Stations	Run 4
Hole opening to 17"	MWD-GR	717.9~1568.9	Run 5
Wireline logging run 4	Junk Basket (8-1/4" gauge ring)	(-2.1)~1218.9	
Wireline logging run 5	VSI-16 (WVSP, CVSP and ZOVSP)	(-82.3)~1136.7	Run 6

Table 1. Site C0009A drilling and logging operations. All LWD-MWD and wireline runs were numbered in one sequence starting from MWD to the last run of wireline logging.

Notes: Depths are used here only logging depth below seafloor where depth from the rigfloor to the seafloor is 2081.1 m and datum of the rotary table is 28.3 m.

Available Data

Logging data was recorded by Schlumberger wireline team for wireline logging, and drilling and measurement team for LWD/MWD operations. Data were then processed by Data and Consulting Services (DCS), Schlumberger for sonic velocity measurements, environmental correction, depth matching. CDEX Logging Services Team made depth matching and image processing of the FMI, depth shifting of all logs, mostly after the cruise.

Hole C0009A was drilled with MWD-APWD for the 26 inch hole, with MWD-PowerV for the 12 1/4 inch hole, and with a conventional drilling assembly for hole opening to 17 inches. Wireline logging was conducted in three different runs after opening the cored interval to 12 1/4 inch diameter. MWD data were used as received from the Schlumberger engineer. Wireline data were processed and depth-shifted by the Logging Staff Scientist and logging specialists (see details in the **"Methods"** chapter). Lists of available data from both MWD-LWD and wireline logging are in the tables (**Table 1**).

Processing

Depth shifting: In order to correlate observations from wireline logs with core and cuttings, depth-shifting the data to a common reference datum was required (see **"Introduction"** in the "Methods" chapter for general information on depth reference terminology). We chose to register the depths for the logs to the bottom of 20 inch casing (703.9 mbsf driller's depth or mDSF) due to it's clear appearance in all three logging runs (**Figure 4**). The 20 inch casing, bottom of 26 inch hole, and bottom of 17 inch hole are all clearly detected by caliper and resistivity data in Run 1 of wireline logging, and by caliper data in the second run. The natural gamma ray radiation collected by Run 1 and Run 2 of wireline logging shows a clear increase corresponding to the bottoms of the 20 inch and 17 inch holes, although it may be affected by hole shape. The natural gamma ray radiation collected during VSP operations also shows an increase corresponding to the bottoms of the 17 inch holes.

The depth references for each logging run are listed in **Table 1** as logging depth below seafloor and shown graphically in **Figure 4**. The height of the rotary table (rig floor) is 28.3 m above sea level (presuming minimal variation in this parameter during drilling operations), and the water depth is reported as 2054.0 m. The depths of the wireline logs are all tied to the drillers' depth at the 20-inch casing shoe, located at 2786.2 mDRF (= 703.9 mDSF and equal to 2785.0 mWRF). Therefore 2081.1 m (2785.0 -703.9) is subtracted from the logging depth (WRF) to give the depth below sea floor of the wireline log data corrected relative to the driller's depth. This value is given in mWMSF (referring to the matching of the individual wireline log runs to each other). Using this method, depth WMSF is equivalent in depth to DSF.

FMI images have been corrected for acceleration of the tool during the logging run as well as relative to the other wireline logs. Depths of these corrected data are also referred to as mWMSF (relative to the sea floor).

Environmental Correction: Schlumberger field engineers made primary corrections and details are explained in their end of well report. Further environmental correction was made as part of the staff training program between CDEX and Schlumberger DCS, using depth matched data from reprocessed FMI data in CDEX (details in the "note on QC and reprocessing of FMI imaging").

This processing is required to convert the electrical current in the formation, emitted by the FMI button electrodes, into a gray or color-scale image representative of the conductivity changes. This is achieved through two main processing phases: data restoration and image display.

1) Data Restoration Speed Correction: The data from the z-axis accelerometer is used to correct the vertical position of the data for variations in the speed of the tool ('GPIT speed correction'), including 'stick and slip'. However, 'image-based speed correction' is not applied yet to the data.

Equalization: Equalization is the process whereby the average response of all the buttons of the tool are rendered approximately the same over large intervals, to correct for various tool and borehole effects which affect individual buttons differently. These effects include differences in the gain and offset of the pre-amplification circuits associated with each button, and differences in contact with the borehole wall between buttons on a pad, and between pads.

Button Correction: If the measurements from a button are unreasonably different from its neighbors (e.g. 'dead buttons') over a particular interval, they are declared faulty, and the defective trace is replaced by traces from adjacent good buttons.

EMEX voltage correction: The button response (current) is controlled by the EMEX voltage, which is applied between the button electrode and the return electrode. The EMEX voltage is regulated to keep the current response within the operating range. The button response is divided by the EMEX voltage so that the response corresponds more closely to the conductivity of the formation.

Depth-shifting: Each of the logging runs are 'depth-matched' to a common scale by means of lining up distinctive features of the natural gamma log from each of the tool strings.

2) Image Display Normalization: Once the data is processed, both 'static' and 'dynamic' images are generated. In "static normalization", a histogram equalization technique is used to obtain the maximum quality image. In this technique, the resistivity range of the entire interval of good data is computed and partitioned into 128 color levels. This type of normalization is best suited for large-scale resistivity variations. The image can be enhanced when it is desirable to highlight features in sections of the well where resistivity events are relatively subdued when compared with the overall resistivity range in the section. This enhancement is called "dynamic normalization". By rescaling the color intensity over a smaller interval, the contrast between adjacent resistivity levels is enhanced. It is important to note that with dynamic normalization, resistivities in two distant sections of the hole cannot be directly compared with each other. A 1-m normalization interval is used.

Oriented Presentation: The image is displayed as an unwrapped borehole cylinder (its circumference is derived from the bit size). Several passes can be oriented and merged together on the same presentation to give additional borehole coverage if the tool pads followed a different track. A dipping plane in the borehole will be displayed as a sinusoid on the image; the amplitude of this sinusoid is proportional to the dip of the plane. The images are oriented with respect to north, hence the strike of dipping features can also be determined.

LOG DATA QUALITY

The quality of the wireline log data is mostly assessed by cross-correlating available logs and hole shape. Density-neutron porosity and micro-resistivity images are affected most by borehole conditions. Resistivity and gamma data may be degraded where borehole diameter greatly increases or is washed out. Deep investigation measurements such as resistivity and sonic velocity are least sensitive to borehole conditions. Environmental corrections are applied to the original data immediately after data acquisition at the well site by the field engineer. If necessary, additional correction and data processing are conducted at the data and consulting centers by specialists to reduce these effects. Data quality indicators, sub-divided into three log types: sonic velocity, micro-resistivity images, and other logs except neutron porosity, are shown together with composite logs and lithostratigraphic units (**Figure 5**).

Three different calipers were run for hole diameter measurements. Among them, the 6-arm caliper from EMS provides the best indication (1282.7 mWMSF) of hole shape. Because data are affected by hole shape, resistivity data below 3365 m have poor/medium quality, as the five resistivity curves overlie each other; this may have resulted from a highly fractured formation or failure to reach the formation (**Figure 5**). Micro-resistivity images from FMI are also affected by the borehole shape in the lower part of the hole.

Due to their high sensitivity to hole shape, density and porosity were affected significantly below 3365 m (1282.7 mWMSF). There were unusual density values at several depths, and porosity data exhibit wide variation throughout the measured range. Environmental effects are much to blame for poor quality of those data as Schlumberger confirmed on proper functioning of tools. Post-cruise reprocessing of the data confirmed that density data quality wasn't bad Gamma ray data exhibit a steady trend and does not exhibit any indication of bad quality from the results or tool report. (Additional environmental correction applied at Schlumberger base will be added here when CDEX receives final report).

Moreover, the wire tension indicates that the logging tool motion was not smooth. The hole diameter indicates that the borehole is quite good from top to 3366mBRT (1284.9 mWMSF), but the borehole below 1284.9 mWMSF is rugose and washed out.

Acoustic Data: Sonic velocity data processing and quality

Immediately after data acquisition, sonic velocity data was sent to Schlumberger's Tokyo Data and Consulting Service (DCS) for further processing. Due to the large data volume from the SonicScanner tool, data was sent by delivery service than V-SAT data transfer. The processing procedure includes extracting compressional, shear, and Stoneley velocities using BestDT, a sonic processing module on Schlumberger's GeoFrame software. The processed data and report were then sent back to the *Chikyu* and delivered to the onboard science party.

Repeatability

To ensure data quality, repeat runs were made for each run over 101.5 m for Run 1 and 85.6 m for Run 2, and comparisons were made between several logs to confirm the repeatability of the data. The comparison between the main and repeat sections indicates good correlation between two logs except for the neutron porosity. Indeed, the large scatter and large value of the neutron porosity of the logs raised doubts, if you will, about the quality of the recording. Neutron porosity is affected by standoff and is not reliable in zones of washout, breakouts, and significant borehole rugosity. By restricting the data to a zone of small standoff (HRDD Standard

References

Saffer, D., McNeill, L., Araki, E., Byrne, T., Eguchi, N., Toczko, S., Takahashi, K., and the Expedition 319 Scientists, 2009. NanTroSEIZE Stage 2: NanTroSEIZE riser/riserless observatory. *IODP Prel. Rept.,* 319. doi:10.2204/iodp.pr.319.2009

Figure Captions

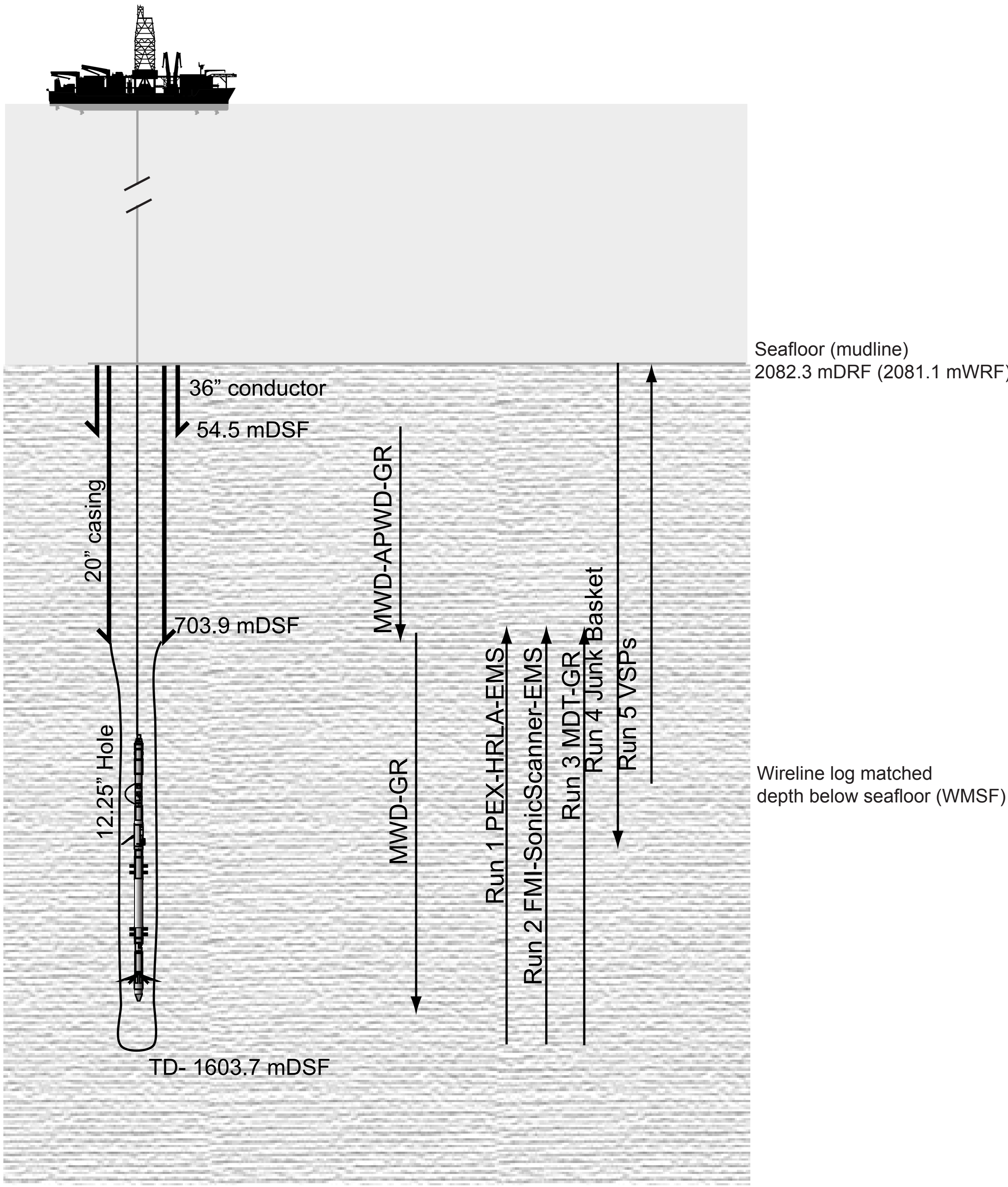
Figure 1. Downhole logging runs at Hole C0009A.

Figure 2. MWD-LWD toolstrings used in the Expedition 319.

Figure 3. Wireline logging toolstrings used in the Expedition 319.

Figure 4. Reference depths and correlation between depth scales.

Figure 5. Composite wireline logs collected from the runs #2 and #3 and their data quality indicators (green=good, yellow=medium, black=poor).



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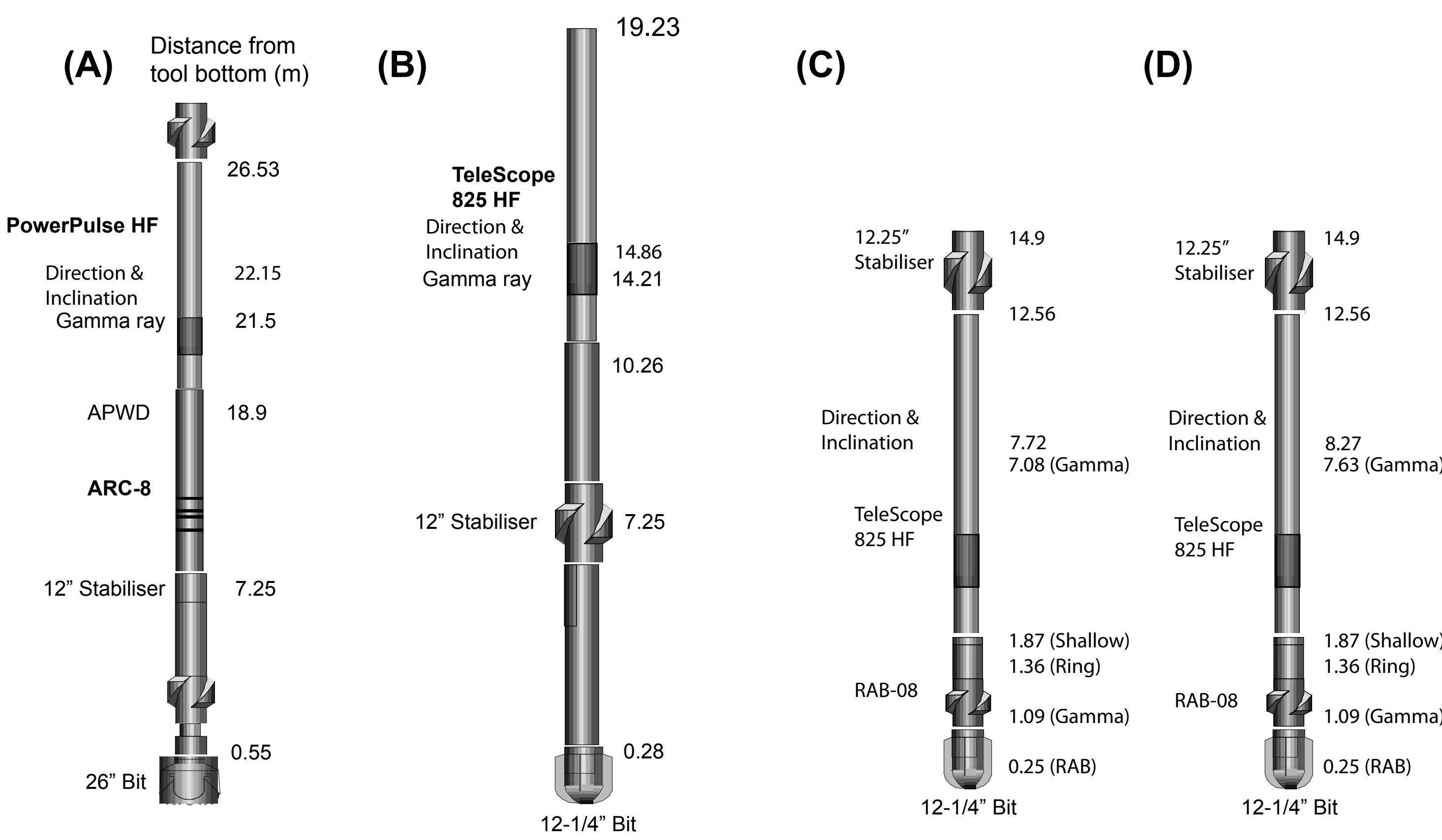
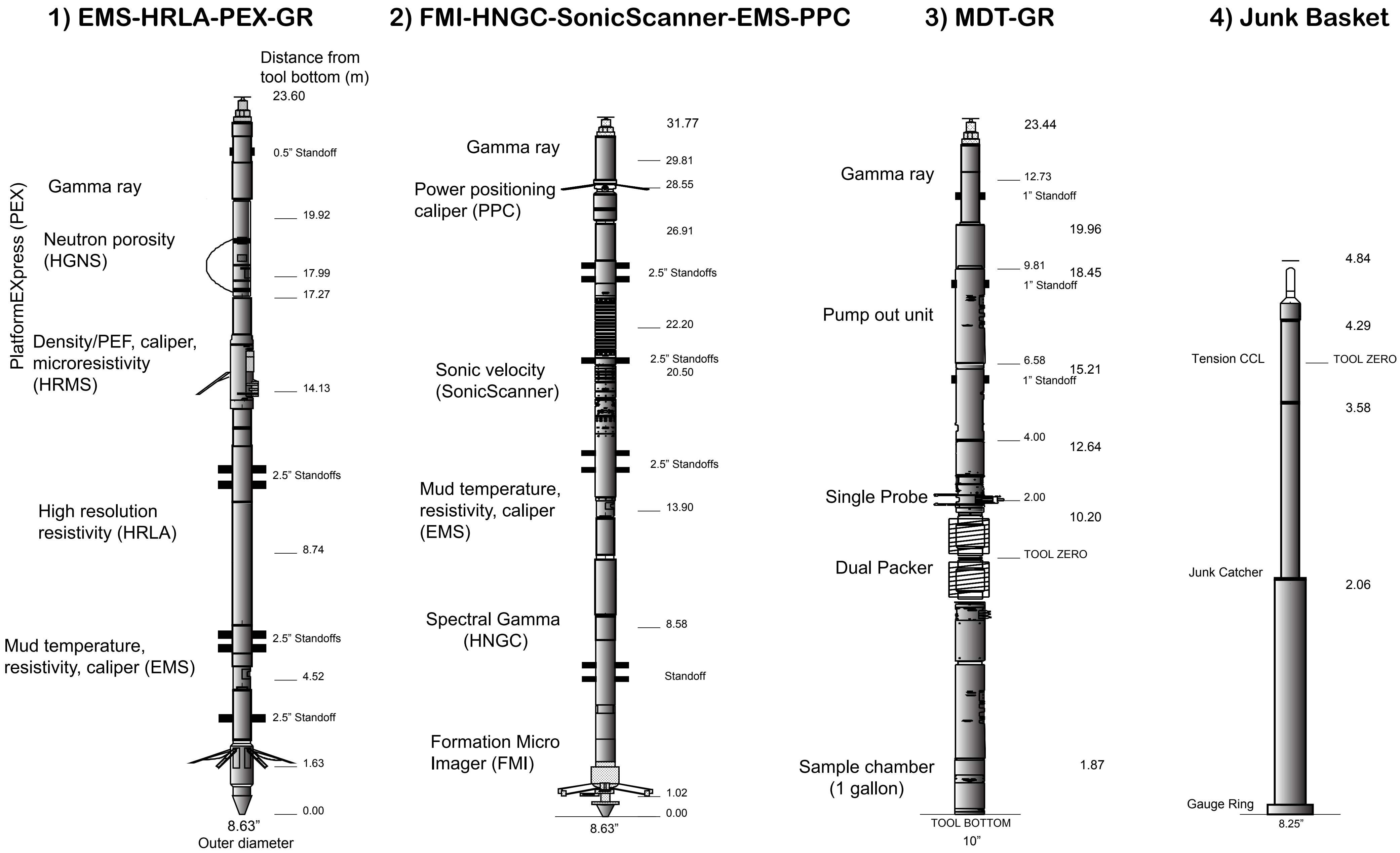


Figure 2. MWD-LWD toolstrings used in the Expedition 319, (A) 26 inch hole drilling between seafloor and 711.8 m LSF, (B) 12.25 inch hole drilling between 707.7 and 1509.7 m LSF at Site C0009A, (C) for 12.25 inch hole drilling between 41 and 555 mLSF at Site C0010A, (D) for !2.25 inch hole from seafloor to the 952 mLSF at Site C0011a.

Figure 3. Wireline logging toolstrings used in the Expedition 319.



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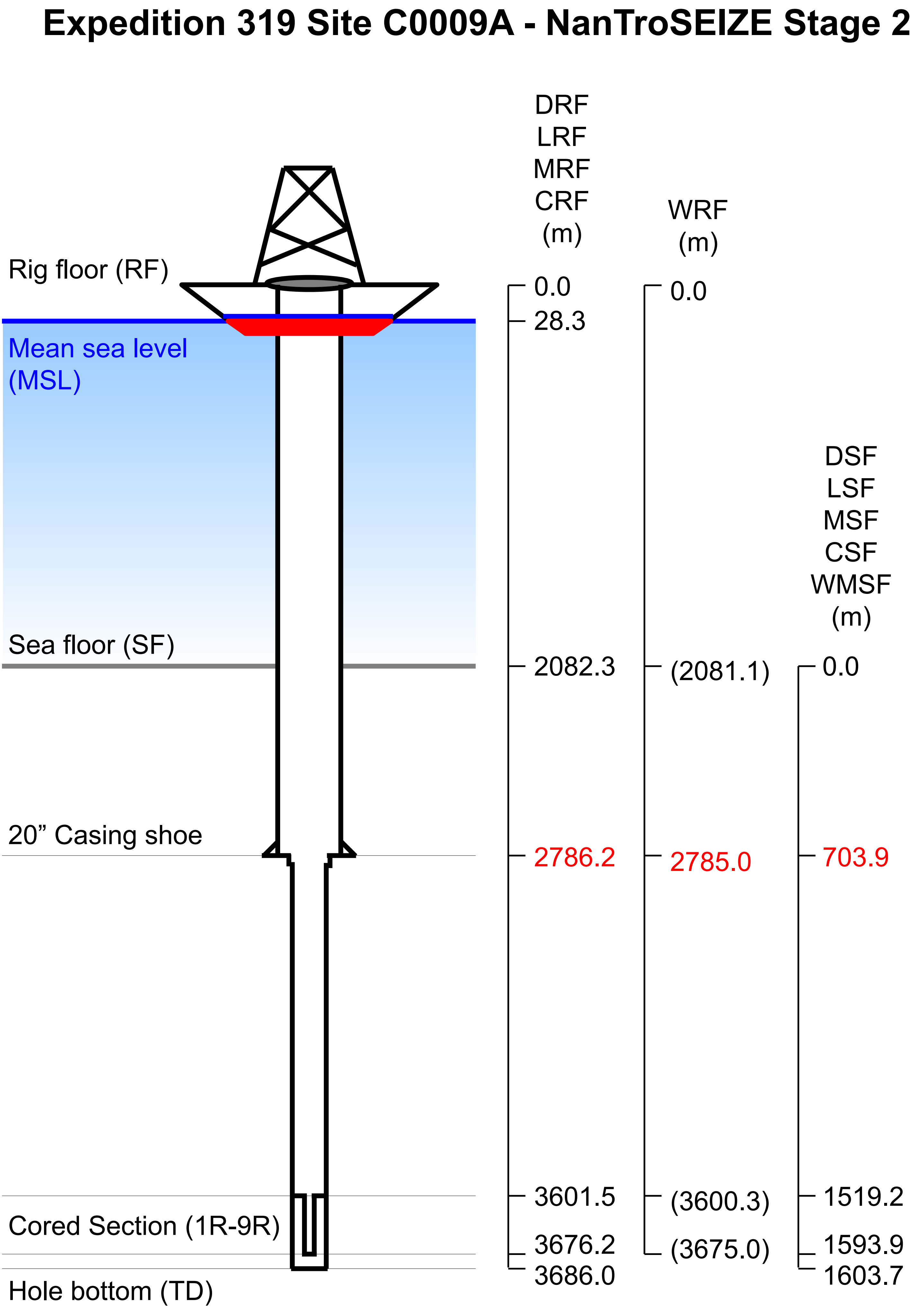

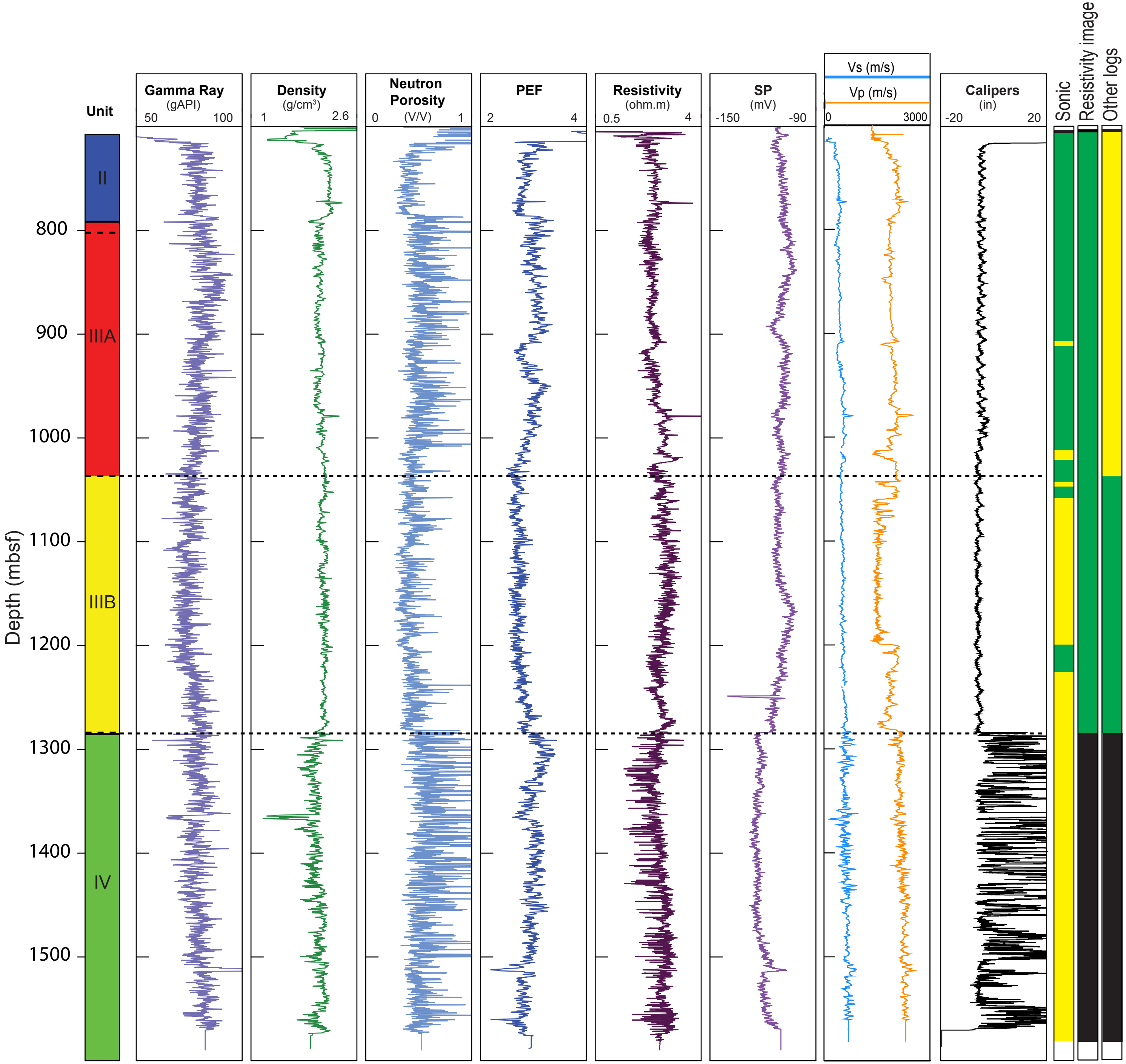

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