IODP Expedition 314 processing note

Operation summary

Hole C0001D

Latitude: 33°14.3286'N

Longitude: 136°42.7040'E

Seafloor (drill pipe measurement from rig floor, m): 2228.0

Distance between rig floor and sea level (m): 28.5

Water depth (drill pipe measurement from sea level, m): 2199.5

Logging run

LWD(geoVISION-sonicVISION-adnVISION-seismicVISION)-MWD-APWD

Available data

Hole C0001D were drilled with LWDMWD-APWD tools installed in the drill string. Similar to All MWD-APWD data were transmitted in real time, including a limited set of LWD data. This data set includes bulk density (RHOB_DH_ADN_RT) (g/cm^3) and bulk density correction (DRHO_DH_ADN_RT) (g/cm^3) computed downhole (with a less sophisticated algorithm than the one used at the surface with the memory data); thermal neutron ratio (TNRA_ADN_RT) and thermal neuron porosity (TNPH_ADN_RT) (per unit); average borehole diameter from the ultrasonic caliper (ADIA_ADN_RT) (inch); gamma ray (GR_RAB_RT) (gAPI) and resistivities (bit [RES_BIT_RT], ring [RES_RING_RT], shallow [RES_BS_RT], medium [RES_BM_RT], and deep [RES_BD_RT]) (Ohrm-m) from the GVR tool; hole deviation data such as relative bearing (RB_RT) (degree); hole azimuth (HAZI_RT) (degree), and hole deviation (DEVI_RT) (degree); sonic compressional Δt; and semblance (DTCO) (μs/ft and CHCO) from the sonic tool (see Table **T2**). Realtime transfer of seismic data failed because of problems with the downhole picking of wave arrivals in a high-noise environment. When LWD tools were recovered on the rig floor, various problems were encountered that required modifying the data flow presented in Figure **F8**. Figure **F2** illustrates the data flow used for Hole C0001D. geoVISION memory data were successfully downloaded and converted to depth. Sonic data were downloaded, but merging downhole time data with surface time-depth information initially failed. Both files were sent to Schlumberger's shore base in Shekou (China) for depth conversion preprocessing and then were sent back to the ship for further processing and analysis. Downloading data from the adnVISION tool was impossible on board because of damage to the output port on the tool; therefore, in an attempt to download the data, the tool was sent to the Shekou base. The memory data from the adn-VISION tool were returned to the *Chikyu* shortly before the end of Expedition 314. The seismicVISION tool experienced a similar problem and was sent to the Schlumberger SKK Drilling and Measurement Center (Fuchinobe, Japan), where the data were successfully downloaded and sent back to the ship by file transfer protocol for onboard processing and analysis. For Hole C0001D, transfer of adnVISION real-time data to the surface was lost below 510 m LSF, limiting the set of available data to real-time MWD and memory geoVISION, sonicVISION, and seismicVISION data from 0 to 973 m LSF (2193 to 3201 m DRF). adnVISION memory data for 0–510 m LSF were eventually recovered. However, no memory data for the hole below 510m LSF could be recovered.

Depth shift

For Holes C0001D, the mudline (seafloor) was identified from the first break in the gamma ray (GR) and resistivity (RES_RING, RES_BIT, RES_BD, RES_BM, and RES_BS) logs (Fig. **F3**). In Hole C0001D, the mudline was picked at 2228 m DRF, again differing from drillers depth, this time by 2 m (2226 m DRF). For both holes, uncertainty in picking the mudline is clearly within

±1 m because the top few meters of the unconsolidated formation was washed out by drilling fluid and resulted in mixing (formation suspension) at the mudline interface, blurring gamma ray and resistivity readings. For Hole C0001D, the depth-shifted versions of the main drilling data and geophysical logs are given in Figure **F4,** respectively. Figure **F5** present the time-depth relationship linking the time (Fig. **F1**) and depth (Fig. **F4**) versions of the data from Hole C0001D.

Logging data quality

Figure **F4** shows the quality control logs for the Hole C0001D LWD data. To avoid deviation of the hole as with Hole C0001C, the hole was started with rapid jetting-in (0–55 m LSF). Except for this shallow depth interval, the target ROP of 25 m/h (±5 m/h) was achieved to 340 m LSF. Effective ROP then slightly decreased with local increases in APRS and ECD, requiring minor backreaming (340–520 m LSF). Concomitant with the major increases in APRS and ECD, an increase in SPPA and a decrease in ROP was necessary to maintain drilling fluid circulation (from 520 to TD = 972 m LSF). For this lower depth interval (520–972 m LSF) increased SWOB was necessary to compensate for increasing stick-slip, which was particularly high (>200 rpm) in the high-ECD zone (520–580 m LSF) with a high level of shocks (740–920 m LSF). At ~575 m LSF, the hole slightly deviated by 2°, but hole deviation never exceeded 4° to TD. Except during pipe connections, backreaming, and wiper trips, TAB measurements are ~5–10 min for ring resistivity and 4–8 min for gamma ray logs. Theoretical TAB measurements are ~40–60 min for density/ porosity; however, while real-time density and neutron porosity logs are available, they are limited to the upper section of the hole (0–510 m LSF). adn-VISION memory data for 0–510 m LSF were obtained shortly before the end of Expedition 314. All adnVISION memory and real-time data below 510 m LSF were lost because of tool failure. The ADIA log, which is indicative of borehole condition, is also limited to this depth interval. Except for the 40 m where caliper readings are unreliable, the density caliper shows almost in-gauge value (standoff between tool and the formation = ~1 inch [~2.5 cm] to 190 m LSF). From 190 to 480 m LSF (loss of real-time data) the ADIA is highly anticorrelated with the RHOB, especially where ADIA exceeds 10 inches (25.4 cm) and where DRHOB is underestimated (Fig. **F4**). To fill the gap in ADIA and further assess borehole conditions below 480 m LSF, a comparison between natural gamma ray logs from Holes C0001A (GRM1, MWD tool, and real-time) and C0001D (GR, GVR tool, and memory), horizontally separated by ~65 m, is presented in Figure **F6.** To ~500 m LSF, GRM1 and GR are particularly well correlated, at least at a meter scale, confirming proper reading of both tools. Correlation remains relatively high from 500 to 875 m LSF, except in the following depth intervals: 530–590, 625–650, 730–750, 780–860, and 900–925 m LSF, where GR (Hole C0001D) is lower than GRM1 (Hole C0001A). Careful inspection of the depth and time version of the data reveals that low GR with respect to GRM1 corresponds to periods of SPPA and low ROP in Hole C0001D, suggesting washouts at these depth intervals. SPPA in Hole C0001D is between 15 and 17 MPa, slightly above (1–2 MPa) SPPA in Hole C0001A (note the significant shift in SPPA by ~4 MPa between 522 and 556 m LSF), but most importantly the ROP in Hole C0001D is significantly lower (mostly below 15 m/h) than in Hole C0001A (mostly above 15 m/h). Major decreases in sonic *P*wave velocity (V_P) and resistivity for the two largest intervals (530–590 and 780–860 m LSF) favor this interpretation. Major potential washouts are identified in orange and minor potential washouts in yellow. Scalar logging data in these depth intervals must be interpreted with caution. As for Hole C0001C, comparison between RES_BD and RES_BS resistivity values shows that drilling fluid invasion is null or not significant (even with a slightly lower ROP than in Hole C0001C) and confirm short TAB readings. The sonicVISION data for Hole C0001D were processed on board the *Chikyu* by the Schlumberger Data Consulting Services (DCS) specialist, using two primary filtering sequences. The first "wide" sequence uses a broad bandwidth filter and the second "leaky-P" sequence uses a narrow filter designed to pass leaky *P*-wave mode arrivals. The composite sonic velocity curve that the DCS specialist prepared for this site includes data from both processed logs (Table **T4**). In the upper half of the hole from 0 to 524 m LSF and below 874 m LSF, the wide data were superior and were used to assemble the composite log. From 524 to 874 m LSF, the data from the wide and leaky-P processing were used in the composite. Quality control analysis of the sonic data is based on examination of the plots showing sonic waveforms and slowness coherence images for the common receiver data and common source data (Figs. **F7, F8, F9, F10, F11, F12**). The sonic data from 0 to 175 m LSF show a strong arrival with slowness expected for waves traveling in drilling fluid (an example of data in this interval is shown as "mud arrival" in Fig. **F7**). This arrival is expected to be large when the formation velocity is very low. We see no sign of a distinct arrival from the formation. We conclude that the formation velocity must be near that of the mud because if it were higher it would be more distinct. The interval 175–325 m LSF is a region in which there is a clear formation arrival distinct from the mud arrival (examples of data in this interval are shown in Figs. **F8, F9**). The sonic data seem quite continuous and reliable. There is a narrow zone from 192 to 202 m LSF in which the formation slowness drops back into the mud arrival. It is unclear whether this signal is an increase in slowness or a washout in the hole. The interval between 325 and 476 m LSF (Fig. **F10** shows an example of data from this interval) is characterized by reasonably continuous slowness coherence broken by occasional gaps one to several meters thick. The picks in these gaps are usually higher slowness than the neighboring reliable picks. This creates apparent fluctuations in velocity that would be detrimental to the creation of synthetic seismograms. From 476 to 874 m LSF the gaps between reliable picks become larger, until the gaps dominate (an example of data in this interval is shown in Fig. **F11**). At this point, the sonic log is unreliable if used as is, although there are probably good values to be identified by using the coherence plots. From 874 m LSF to the deepest point reached by the sonicVISION tool at 964 m LSF the data improve. The picks are clear and fairly continuous (an example of data in this interval is shown in Fig. **F12**). The following comments on the processed sonicVISION data were provided by the Schlumberger DCS specialist. The compressional slowness curve was labeled based on the basic idea of making a continuous curve. Therefore, for intervals where both monopole *P*wave/ *S*-wave (MPS)-wide, and leaky-P processed data have low coherence and are hard to pick, I labeled it along the basic trend of coherence. Above 172 m LSF, it's hard to say whether labeled slowness is formation compressional or mud arrival. I suggest that it is the mud arrival, because its slowness value is more or less constant at 200 µs/ft. Meanwhile, considering very slow formation with a slowness close to mud, mud arrival could have some interference with the formation signal. Velocities in the interval 422 to 872 m LSF are less accurate. In this interval, slowness was picked using both the MPS-wide but also leaky-P processed data. While the leaky-P processing strongly attenuates noise traveling through the mud and the tool, leaky-P transmission is dispersive and this can lead to poor picks if the filter band-pass is not exactly right. Note leaky-P processing is applicable only to very slow or extremely slow formations and should not be used to process data for fast or intermediate formations. Overall, the quality of the resistivity image data is good in Hole C0001D (Fig. **F4;** Table **T5**). Except for two short intervals (541–543 and 602–603 m LSF) showing a stick-slip vertical line indicative of nonrotation of the GVR tool/stick-slip, consistency in image quality between the shallow, medium, and deep data is indicative of good quality. From 529 to 629 m LSF, where hole problems occurred, data losses are more common, but even in this section the general structural patterns are apparent.

This note is extracted from

Kinoshita, M., Tobin, H., Ashi, J., Kimura, G., Lallement, S., Screaton, E.J., Curewitz, D.,Masago, H., Moe, K.T., and the Expedition 314/315/316 Scientists, Proceedings of the Integrated Ocean Drilling Program, Volume 314/315/316.

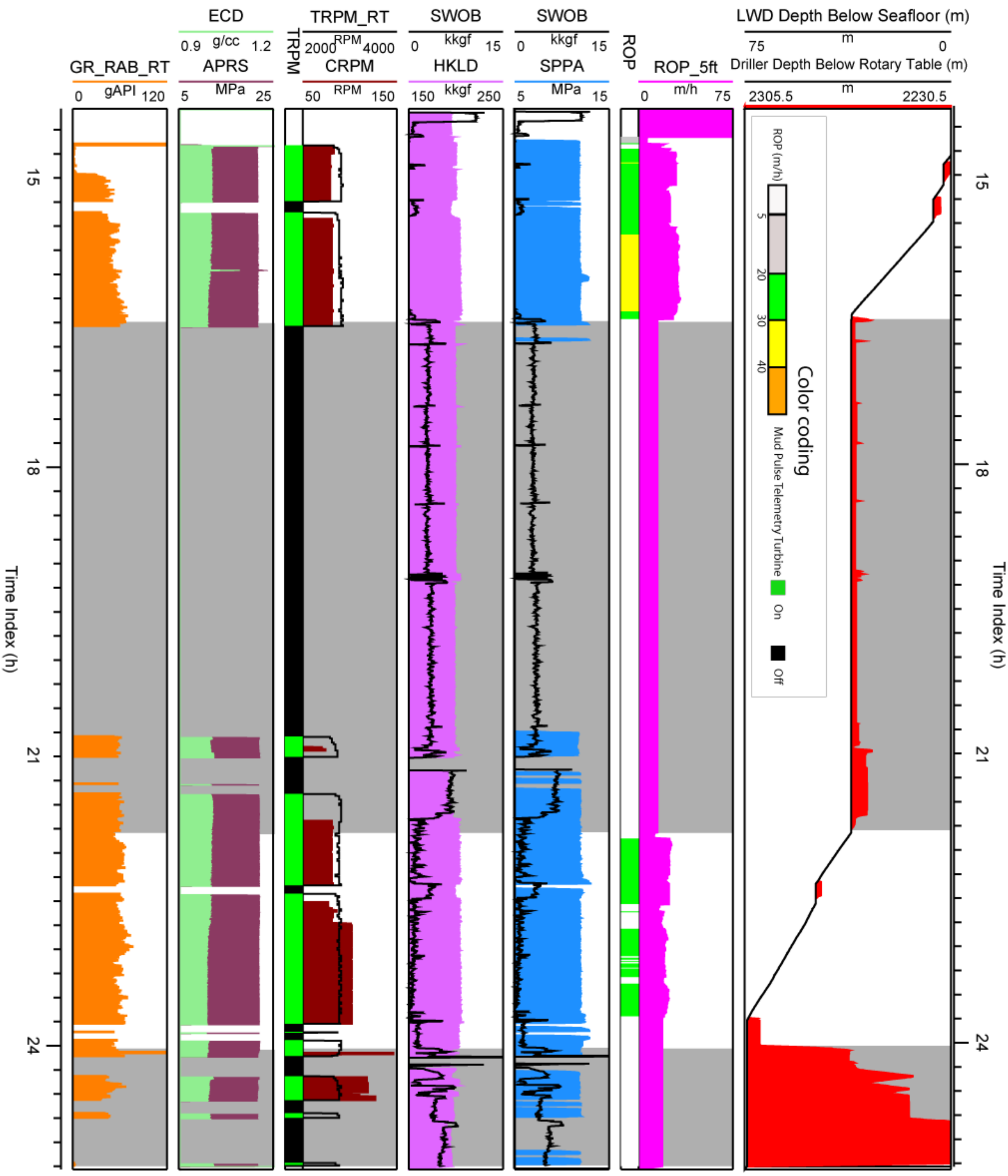

Figure F1. Drilling parameters and gamma ray log plotted vs. time for MWD-APWD operations in pilot Hole C0001D. GR_RAB_RT = gamma ray resistivity-at-the-bit rotation (real time), ECD = equivalent circulating density, APRS = average annular pressure, TRPM = MWD turbine rotation speed (off = <1500 or >4500 rpm, on = 1500–4500 rpm), TRPM_RT = TRPM (real time), CRPM = collar rotation, SWOB = surface weight on bit, HKLD = hook load, SPPA = standpipe pressure, ROP = rate of penetration, ROP_5ft = 5 ft averaged ROP, LSF = LWD depth below seafloor, DRF = drillers depth below rig floor.

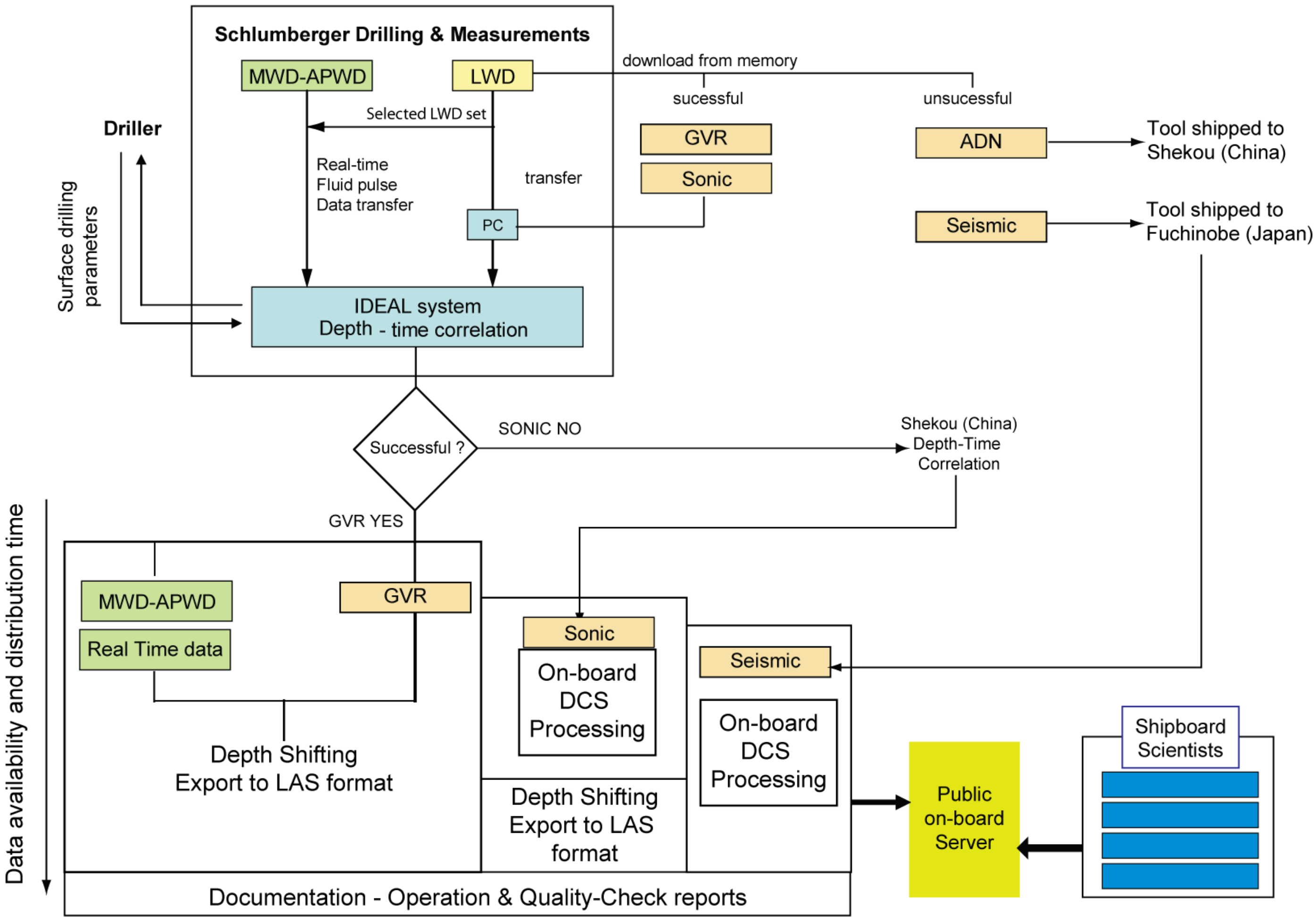

Figure F2. Data flow for Hole C0001D. MWD = measurement while drilling, APWD = annular pressure while drilling, LWD = logging while drilling, IDEAL = integrated drilling evaluation and logging system (Schlumberger), GVR = geoVISION resistivity tool, ADN = Azimuthal Density Neutron tool (adnVISION), LAS = log ASCII standard format, DCS = Data Consulting Service (Schlumberger).

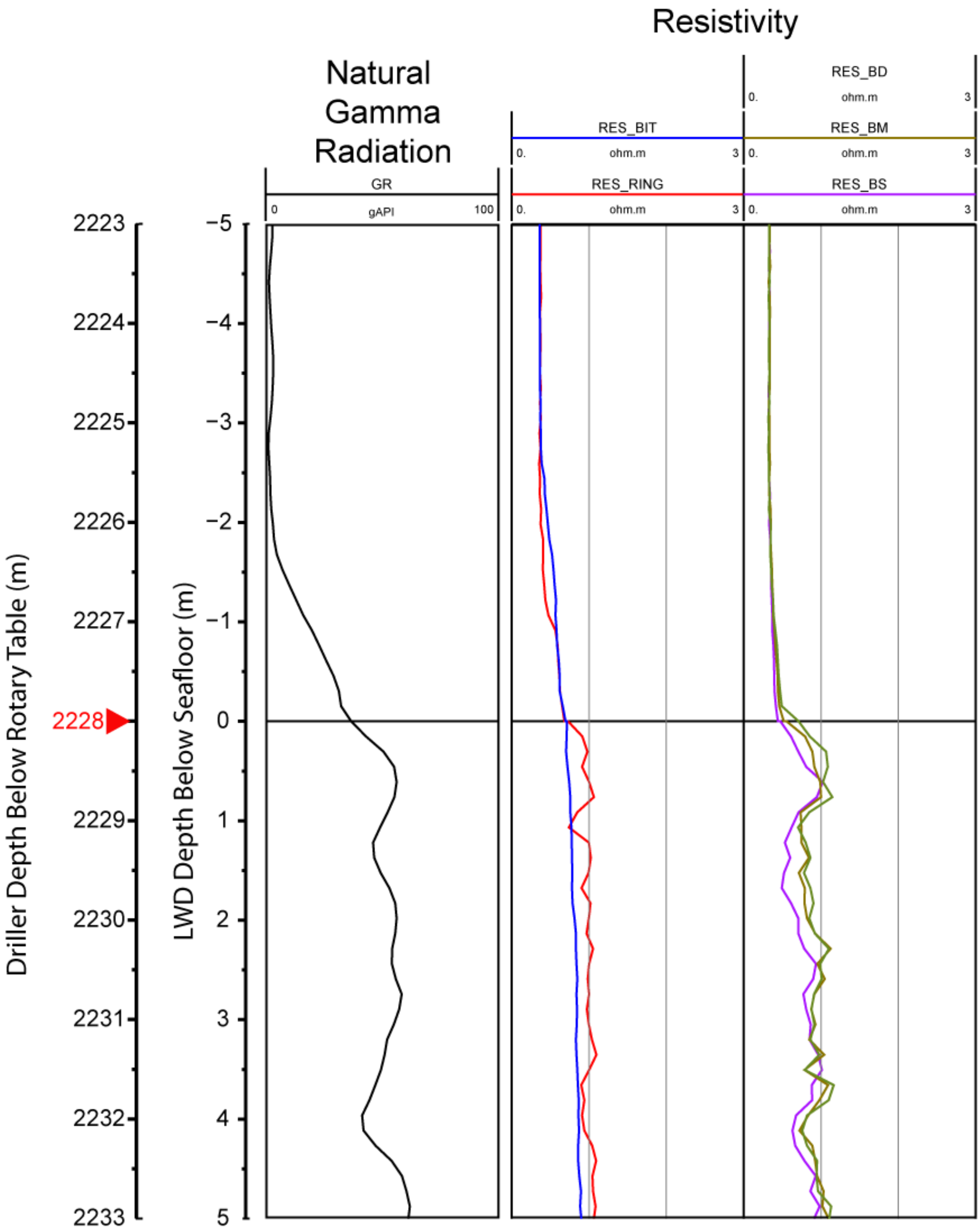

Figure F3. Identification of mudline in Hole C0001D using gamma ray and resistivity logs of the geoVISION tool (memory data). Mudline is identified by a break in the gamma ray and resistivity logs at 2228 m drillers depth below rig floor (DRF). Note that resistivity data are plotted on a linear scale. LSF = LWD depth below seafloor.

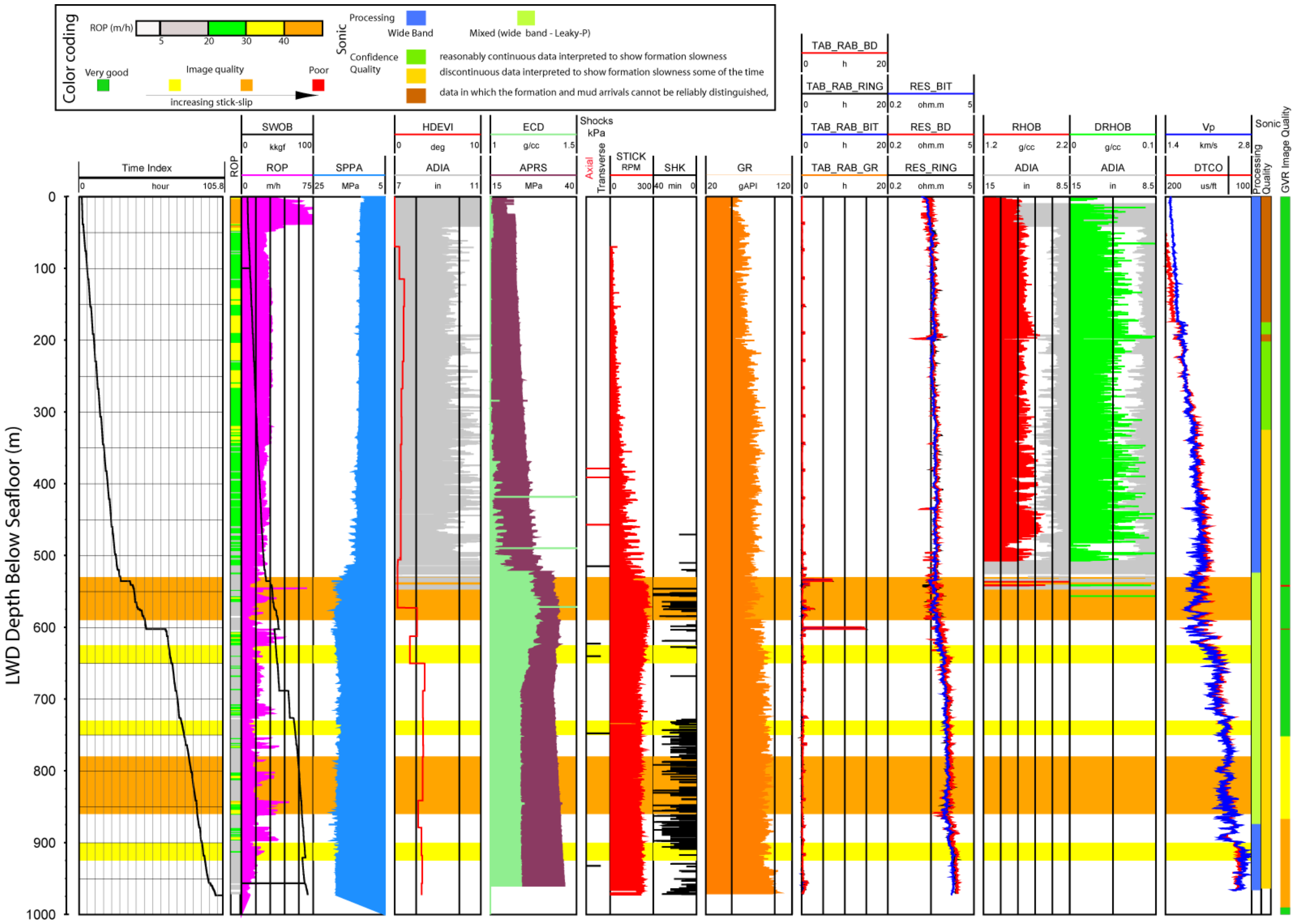

Figure F4. Control logs of Hole C0001D. LSF = LWD depth below seafloor, SWOB = surface weight on bit, ROP = rate of penetration, SPPA = standpipe pressure, HDEVI = hole deviation, ADIA= average borehole diameter, ECD = equivalent circulating density, APRS = average annular pressure, STICK = stick slip indicator, SHK= shock indicator, GR = gamma ray, TAB_RAB_BD = time after bit deep button resistivity, TAB_RAB_RING = time after bit ring resistivity, TAB_RAB_BIT = time after bit resistivity, TAB_RAB_GR = RAB gamma ray time after bit, RES_BIT = resistivity-at-the-bit, RES_ BD = deep button resistivity, RES_RING = resistivity at ring, RHOB = bulk density, DRHO = bulk density correction, V_P = sonic velocity, DTCO = compressional wave slowness, GVR = geoVISION resistivity tool. First vertical color-coded sonic column is indicative of the processing (blue = mostly wide frequency algorithm/processing, green = combination of wide and leaky-P processing). The second vertical column is indicative of data confidence (green = reasonably continuous data interpreted to show formation slowness).

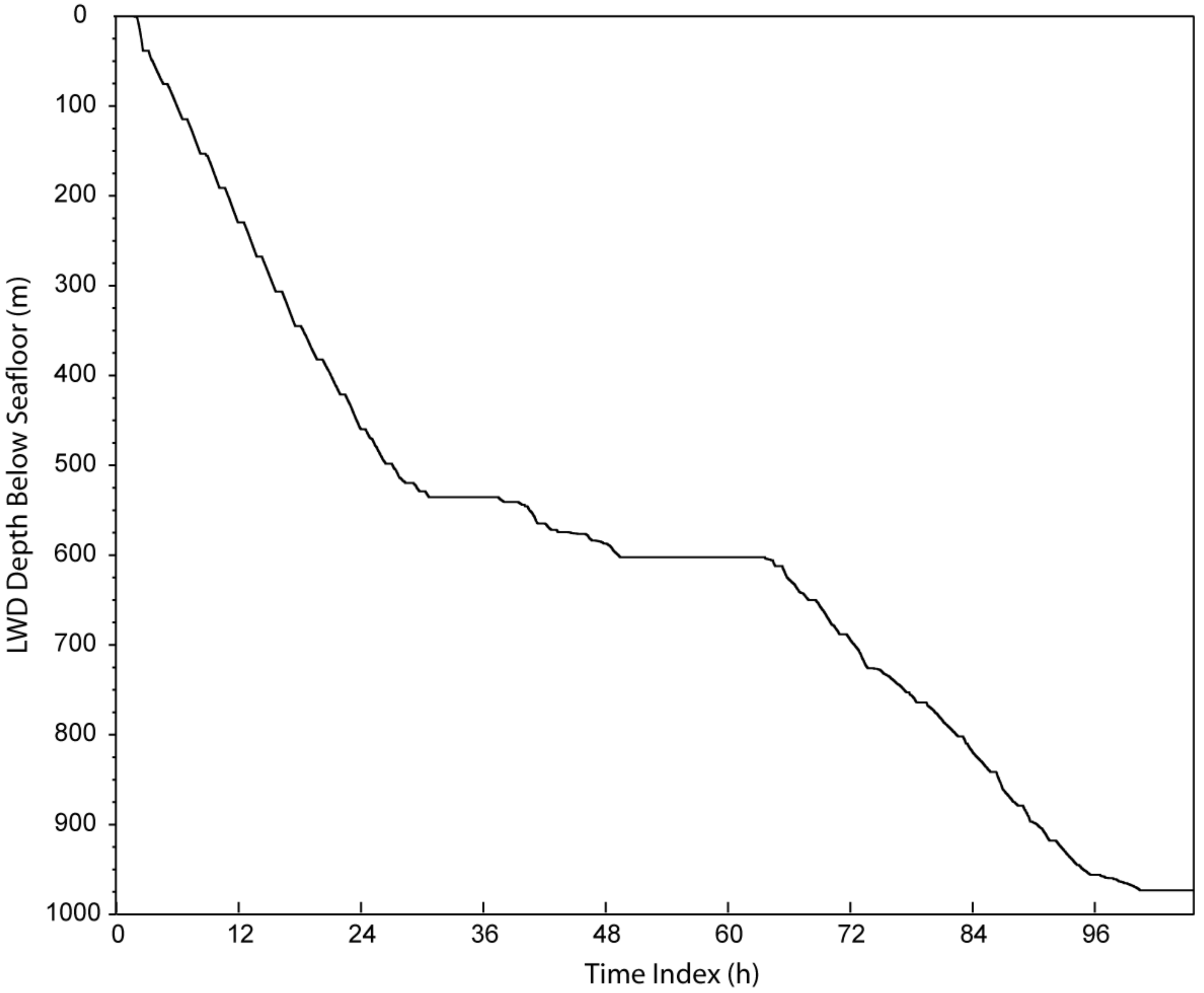

Figure F5. Time-depth relationship in Hole C0001D. LSF = LWD depth below seafloor.

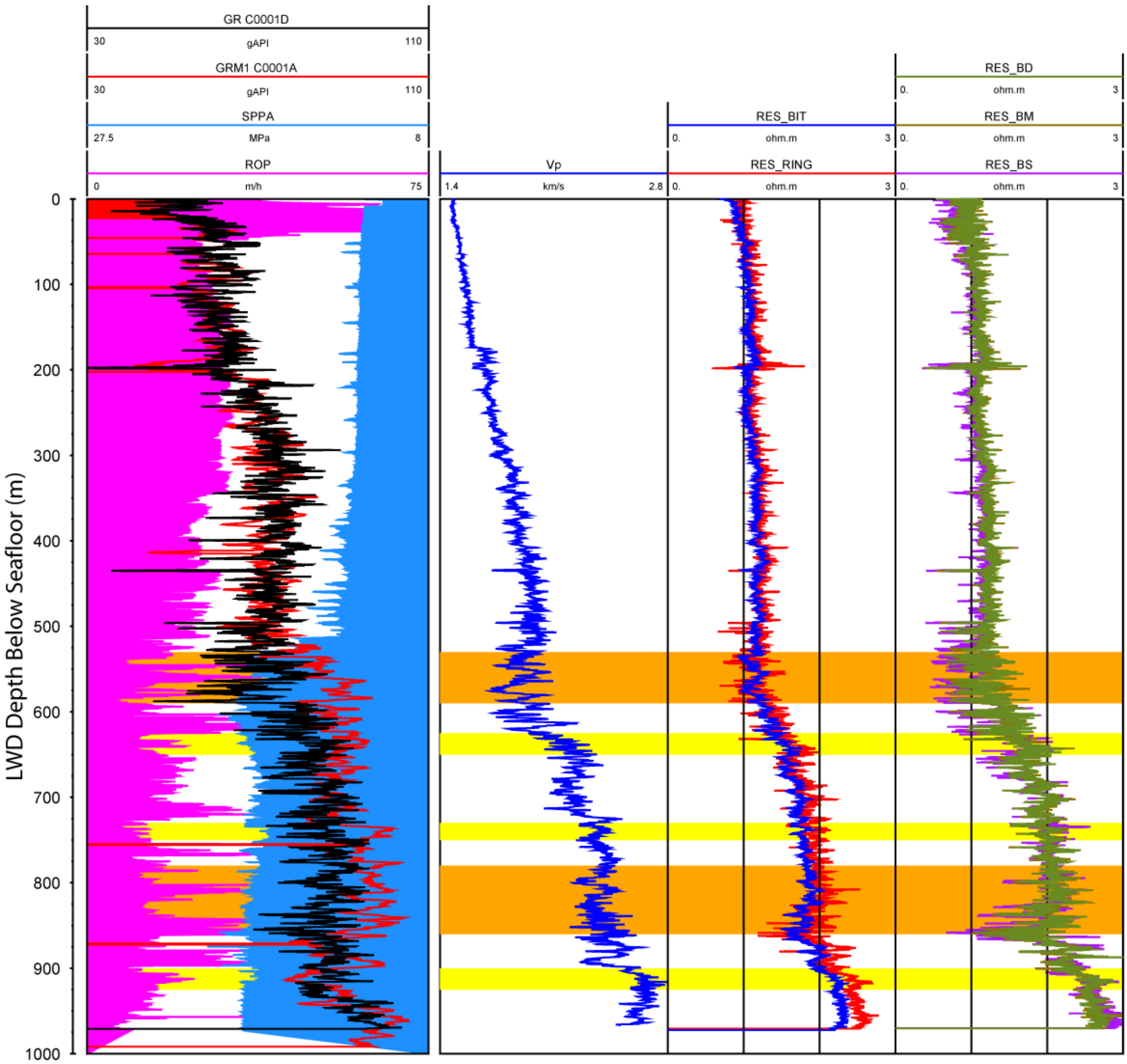

Figure F6. Investigation of borehole condition in Hole C0001D by comparing real-time gamma ray log (GRM1) in Hole C0001A with geoVISION memory gamma ray log (GR) in Hole C0001D. Orange bands = low rate of penetration (ROP) and high standpipe pressure (SPPA) (potential major washouts with possible impact on sonic and resistivity data), yellow bands = potential minor washouts associated either with higher ROP and/ or lower SPPA (no noticeable effects on the deep investigation measurements such as V_P and resistivity). LSF = LWD depth below seafloor.

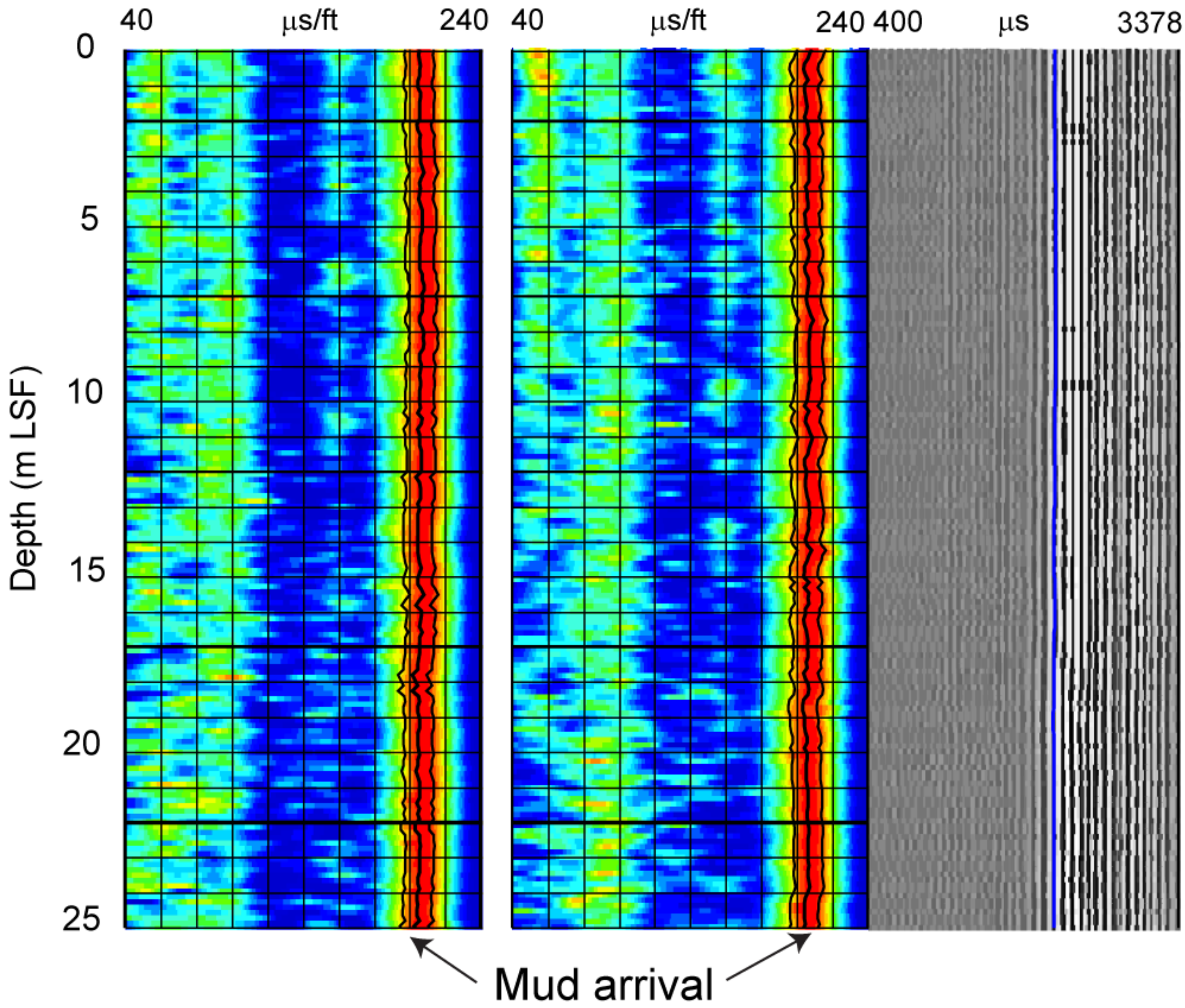

Figure F7. sonic VISION tool sonic log quality control plot from 0 to 25 m LWD depth below seafloor (LSF). Color panels = slowness coherence plots for the common source and common receiver configurations of the tool. Horizontal axis = slowness, with higher slowness (lower velocity) to the right. Warm colors = high signal strength at a particular slowness. Black lines = manual picks made by Schlumberger Data Consulting Services specialist. Gray-scale plot shows seismograms with time increasing to the right. Blue line = arrival pick associated with slowness identified in picks on left. Final slowness value at a depth is given by the mean of the slownesses picked in the common source and common receiver configurations. This serves to compensate for tool position in the hole.

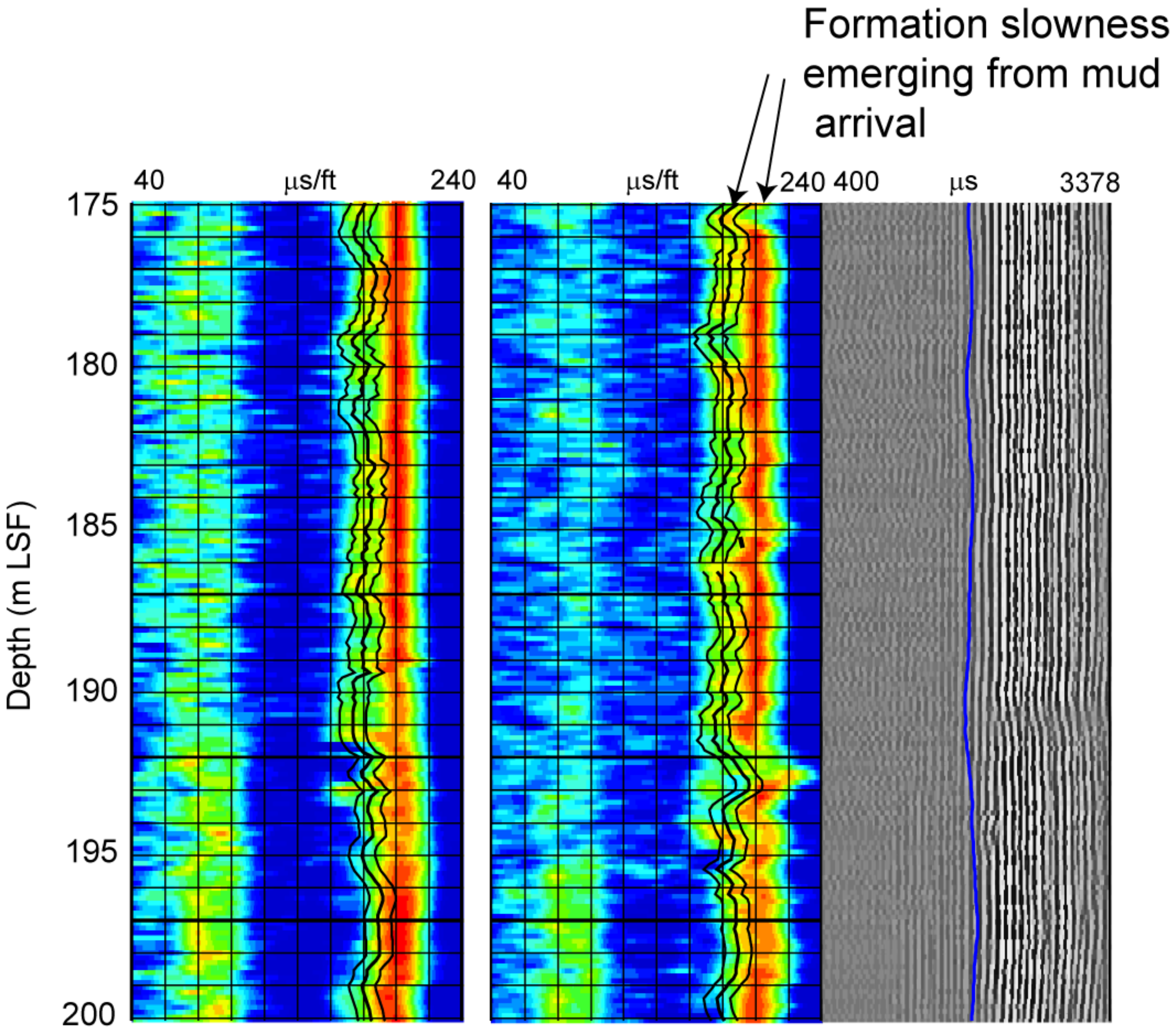

Figure F8. Sonic log quality control plot from 175 to 200 m LWD depth below seafloor (LSF). Color panels are slowness coherence plots for the common source and common receiver configurations of the tool. Horizontal axis is slowness, with higher slowness (lower velocity) to the right. Warm colors = high signal strength at a particular slowness. Black lines = manual picks made by Schlumberger Data Consulting Services specialist. Grayscale plot shows seismograms with time increasing to the right. Blue line = arrival pick associated with slowness identified in picks on left. Final slowness value at a depth is given by the mean of the slownesses picked in the common source and common receiver configurations. This serves to compensate for tool position in the hole.

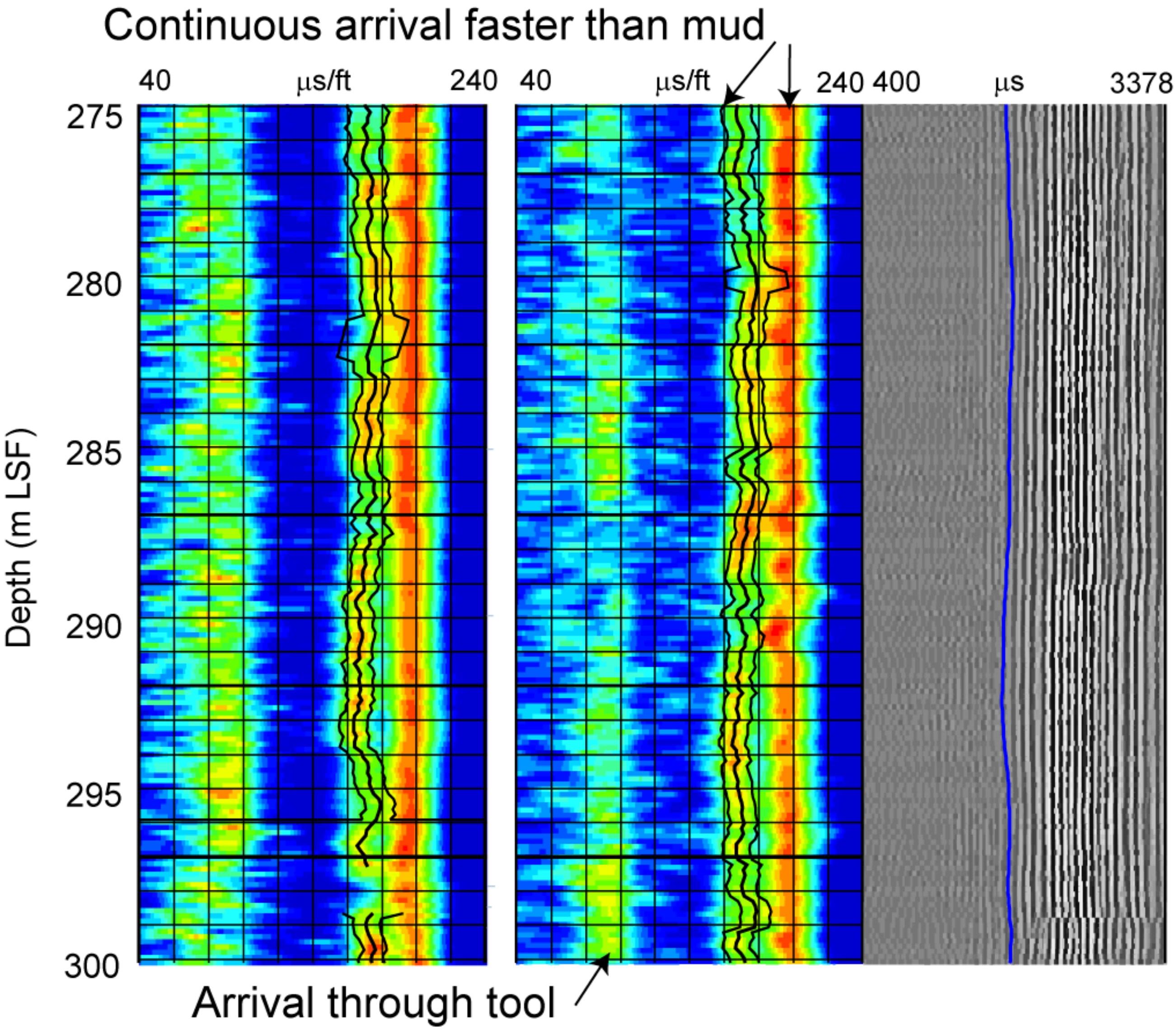

Figure F9. Sonic log quality control plot from 275 to 300 m LWD depth below seafloor (LSF). Color panels are slowness coherence plots for the common source and common receiver configurations of the tool. Horizontal axis is slowness, with higher slowness (lower velocity) to the right. Warm colors = high signal strength at a particular slowness. Black lines = manual picks made by Schlumberger Data Consulting Services specialist. Grayscale plot shows seismograms with time increasing to the right. Blue line = arrival pick associated with slowness identified in picks on left. Final slowness value at a depth is given by the mean of the slownesses picked in the common source and common receiver configurations. This serves to compensate for tool position in the hole.

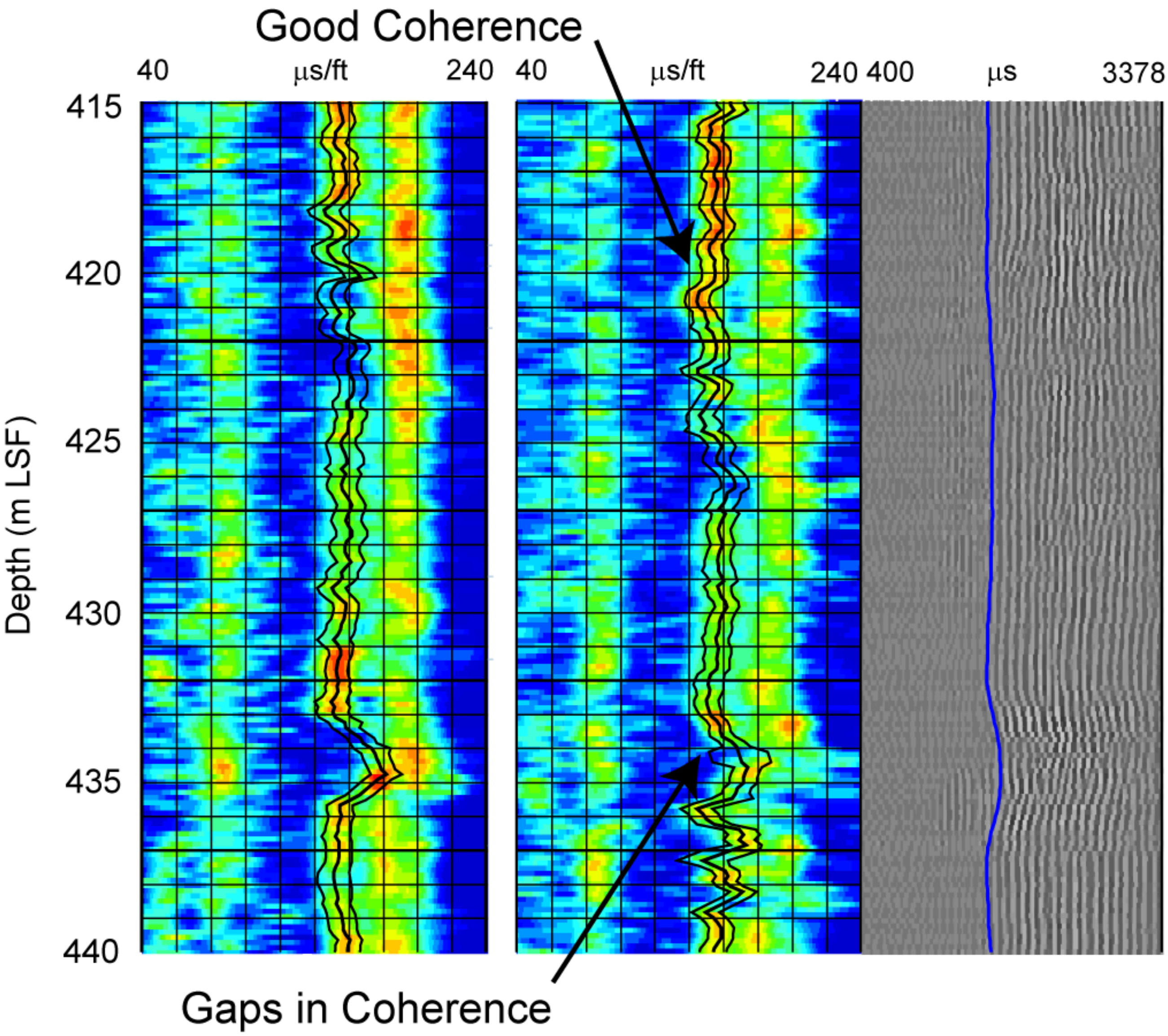

Figure F10. Sonic log quality control plot from 415–440 m LWD depth below seafloor (LSF). Color panels are slowness coherence plots for the common source and common receiver configurations of the tool. Horizontal axis is slowness, with higher slowness (lower velocity) to the right. Warm colors = high signal strength at a particular slowness. Black lines = manual picks made by Schlumberger Data Consulting Services specialist. Grayscale plot shows seismograms with time increasing to the right. Blue line = arrival pick associated with slowness identified in picks on left. Final slowness value at a depth is given by the mean of the slownesses picked in the common source and common receiver configurations. This serves to compensate for tool position in the hole.

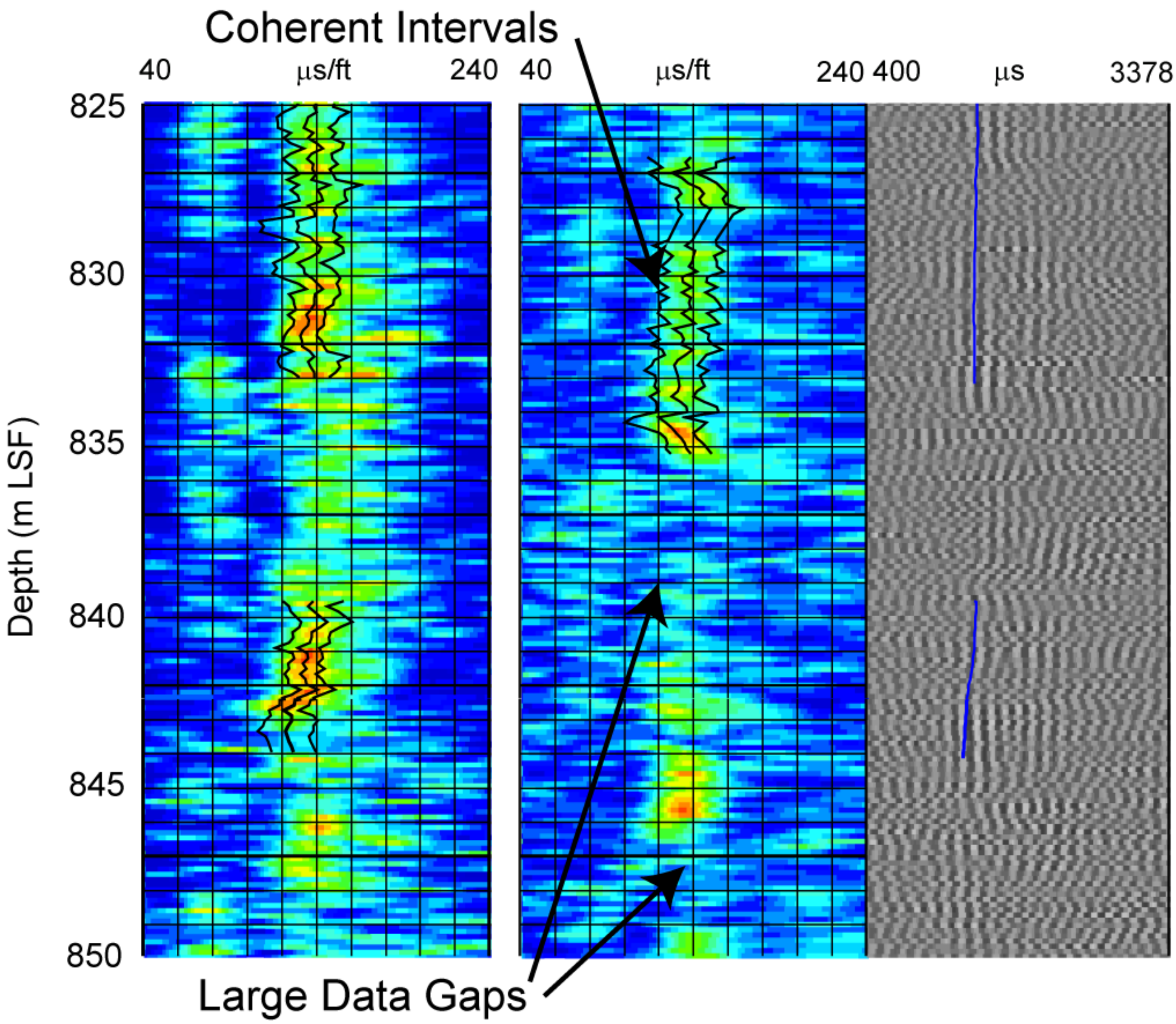

Figure F11. Sonic log quality control plot from 825–850 m LWD depth below seafloor (LSF). Color panels are slowness coherence plots for the common source and common receiver configurations of the tool. Horizontal axis is slowness, with higher slowness (lower velocity) to the right. Warm colors = high signal strength at a particular slowness. Black lines = manual picks made by Schlumberger Data Consulting Services specialist. Grayscale plot shows seismograms with time increasing to the right. Blue line = arrival pick associated with slowness identified in picks on left. Final slowness value at a depth is given by the mean of the slownesses picked in the common source and common receiver configurations. This serves to compensate for tool position in the hole.

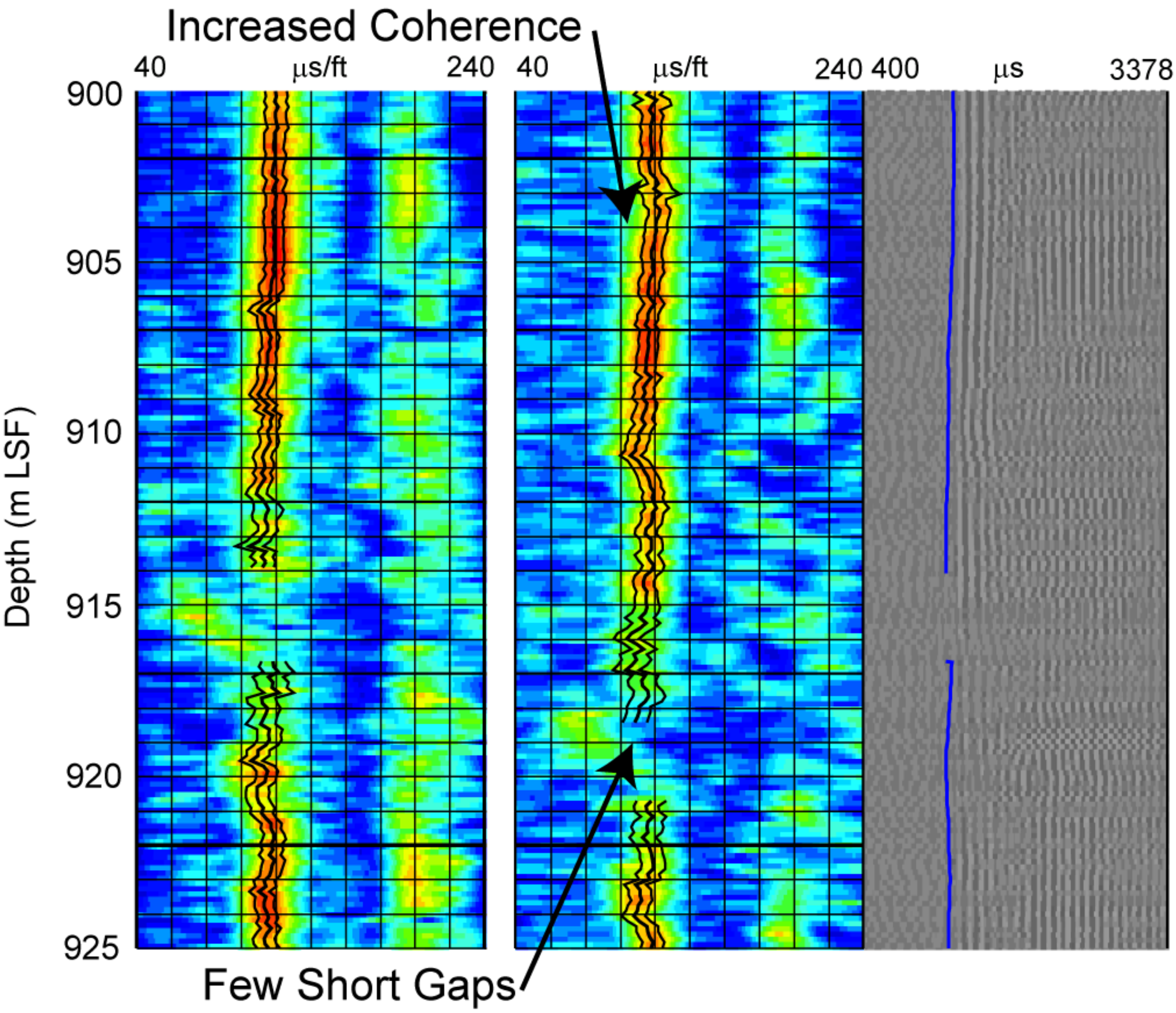

Figure F12. Sonic log quality control plot from 900–925 m LWD depth below seafloor (LSF). Color panels are slowness coherence plots for the common source and common receiver configurations of the tool. Horizontal axis is slowness, with higher slowness (lower velocity) to the right. Warm colors = high signal strength at a particular slowness. Black lines are manual picks made by Schlumberger Data Consulting Services specialist. Grayscale plot shows seismograms with time increasing to the right. Blue line = arrival pick associated with slowness identified in picks on left. Final slowness value at a depth is given by the mean of the slownesses picked in the common source and common receiver configurations. This serves to compensate for tool position in the hole.

Table T1. Operations summary, Site C0001.

Hole C0001D
Latitude: 33°14.32862N
Longitude: 136°42.70402E
Seafloor (drill pipe measurement from rig floor, m): 2226
Distance between rig floor and sea level (m): 28.5
Water depth (drill pipe measurement from sea level, m): 2197.5

Operation	Start		End		Depth (m LSF)		Drilled	Comments
	Date	Time	Date	Time	Top	Bottom	(m LSF)	
C0001D-LWD hole	2-Oct		7-Oct		0	976	976	8.5″ LWD (GVR-SWD-SVWD-MWD-APWD-ADN)
ROV Survey	2-Oct	5:30	2-Oct	6:30				
Seafloor Tagging								
Spud-in	2-Oct	7:40						
Back reaming and seeping								
Rig floor maintenance	4-Oct	7:30	4-Oct	16:15				Short trip 2600 for WL BOP maintenance,
Reaming and Sweeping	3-Oct	12:45	3-Oct	18:30				Sticky hole condition needed reaming and sweeping
Reach Total Depth	6-Oct	10:30	6-Oct	10:30	0	976	976	adnVISION lost communication for real-time monitor.
Pull Tools out of Hole	6-Oct	12:00	7-Oct	0:00				
Recover tools on the rig-floor	7-Oct	0:00	7-Oct	9:00				
Recover Data	7-Oct	1:00	7-Oct	6:00				GVR & sonic data recovered, SVWD data sent to Fuchinobe and ADN to China

Notes: DRF = drillers depth below rig floor, LSF = LWD depth below seafloor. MWD = measurement while drilling, APWD = annular pressure while drilling, ADN = Azimuthal Density Neutron tool (adnVISION). LWD = logging while drilling, GVR = geoVISION resistivity tool. sonic = sonic while drilling (sonicVISION), SVWD = seismicVISION while drilling, GR = gamma radiation. ROV = remotely operated vehicle. R/I = radioactive, POOH = pull out of hole, WL = wireline, BOP = blowout preventer, HPCS = hydraulic piston coring system, DRT = drillers depth below rotary table.

Table T3. Bottom-hole assembly, Hole C0001D.

Description	Length (m)	Cumulated Length from Bit (m)
PDC bit	0.320	0.320
Bit sub	0.610	0.930
Cross-over sub	0.612	1.542
GVR-VISION	3.065	4.607
Sonic-VISION	7.620	12.227
Power Pulse	8.555	20.782
Seismic-VISION	4.635	25.417
ADN-VISION	6.252	31.669
Cross-over sub	0.610	32.279
6 3/4 Drilling collar	9.315	41.594
6 3/4 Drilling collar	9.319	50.913
6 3/4 Drilling collar	9.313	60.226
6 3/4 Drilling collar	9.315	69.541
6 3/4 Drilling collar	9.316	78.857
6 3/4 Drilling collar	9.313	88.170
6 3/4 Drilling collar	9.315	97.485
6 3/4 Drilling collar	9.314	106.799
6 3/4 Drilling collar	9.314	116.113
6 3/4 Drilling collar	9.318	125.431
6 3/4 Drilling collar	9.315	134.746
6 3/4 Drilling collar	9.314	144.060
Jar	10.095	154.155
6 3/4 Drilling collar	9.314	163.469
6 3/4 Drilling collar	9.314	172.783
Cross-over sub	0.610	173.393
Heavy weight drill pipes	185.687	359.080
Cross-over sub	0.610	359.690
Cross-over sub	0.605	360.295

Note: BHA = bottom-hole assembly, PDC = polycrystalline diamond compact.

Table T4. Quality control characteristics and sonic log data, Hole C0001D.

Intervals (m LSF)				
Top	Base	Zone	Quality	Comments
-12	0	1	0	Strong arrivals at about 203 µs/f. No apparent change in the arrivals as the tool crosses the
0	31	1	0	Strong arrivals at about 203 µs/f. No apparent coherence at slowness less than mud velocity
31	84	1	0	Strong arrvals at about 200 µs/f. Not clear if this is due to change in mud velocity. Occasional short (~1 m) increases in slowness of the mud arrival.
84	175	1	0	Strong arrivals at about 195 µs/f. Not clear if this is mud velocity or the emergence of formation velocity.
175	192	1	1	Distinct formation and mud arrivals. Formation arrival variable around 180 µs/ft.
192	202	1	0	No distinct separation between formation and mud arrival. Slowness varies around 195 µs/ft.
202	325	1	1	Distinct formation and mud arrivals. Formation slowness variable around 180 µs/f and dropping gradually with depth (Fig. C0001-QC-F3).
325	476	1	2	Distinct formation and mud arrivals. Coherence decreases, with occasional gaps several meters thick, in which picks are not clear. Formation slowness more variable with depth.
476	524	1	2	Arrivals are more broken up in depth. The picks seem to be skipping between distinct arrivals creating noisy data with large slowness swings on a scale of 1-5 meters.
524	589	2	2	Arrivals are broken up in depth. The picks seem to be skipping between distinct arrivals
589	822	2	2	Arrivals are broken up in depth. The picks seem to be skipping between distinct arrivals
822	874	2	2	Large (10 to 20 meter) gaps in coherent arrivals. Picks in this range are only sporadically
874	964	1	2	Return to reasonable signal strength and coherence. There are still intervals with data gaps, but 10-20 meter sections have continuous reliable data.

Notes: LSF = LWD depth below seafloor.

Table T5. Quality control characteristics and resistivity image data, Hole C0001D.

Depth Interval (m LSF)		
top	bottom	Comments
	2	Start GVR rotation: Beginning of image log
2	541	Excellent
541	543	Poor
543	602	Excellent
602	603	Poor
603	752	Excellent
752	867	Very good
867	990	Good
	990	End of GVR image log

Note: LSF = LWD depth below seafloor, GVR = geoVISION resistivity tool.