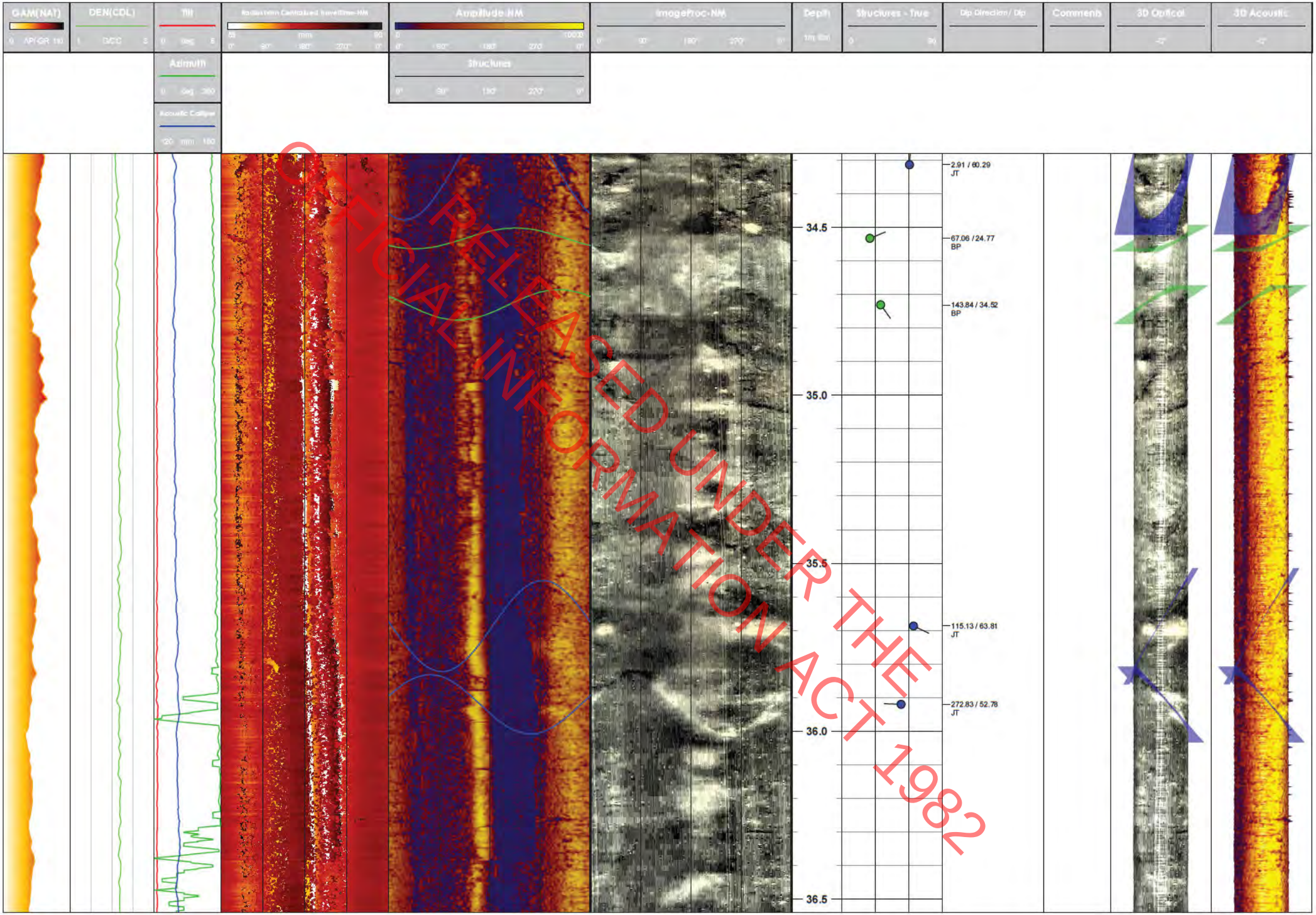

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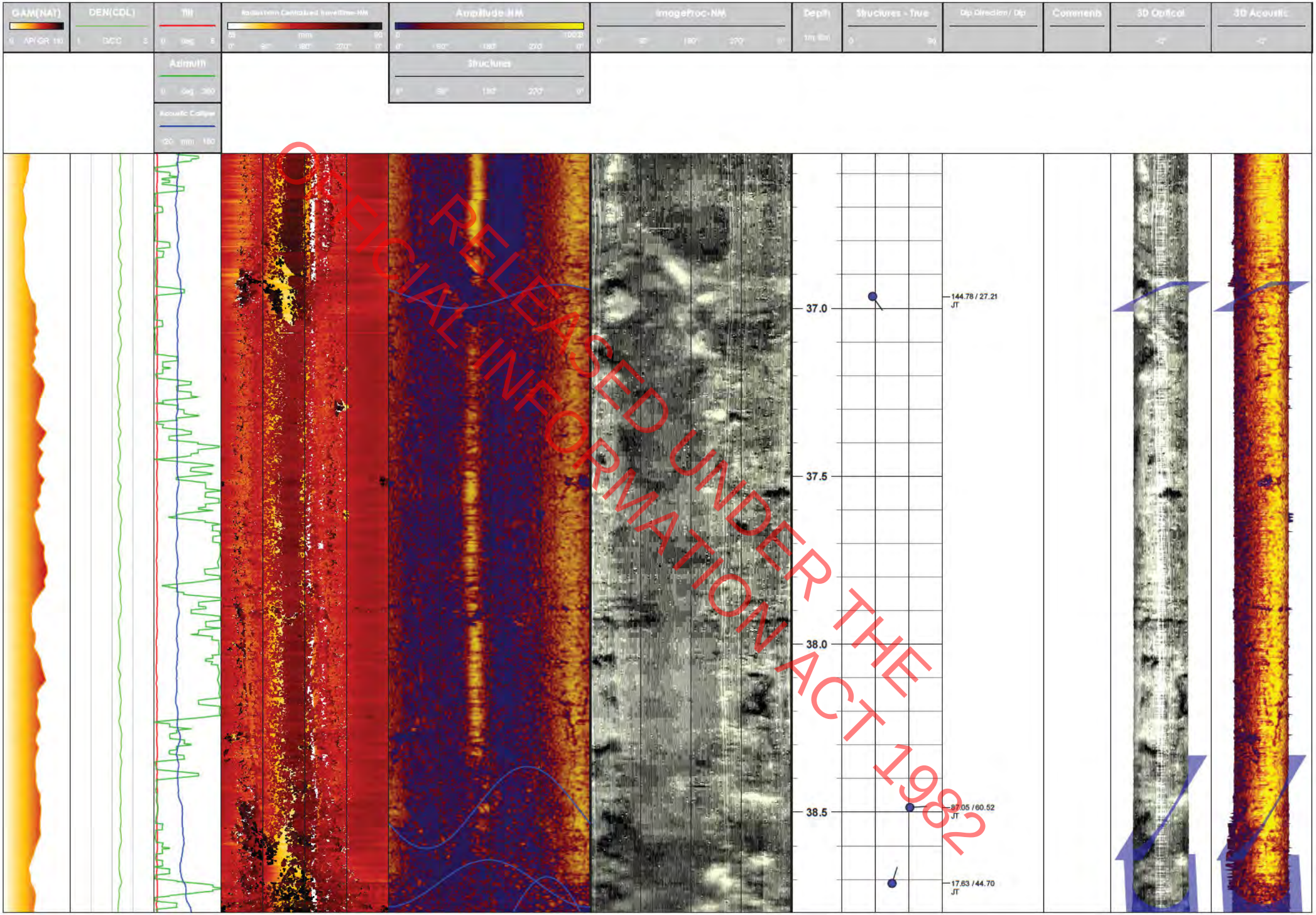

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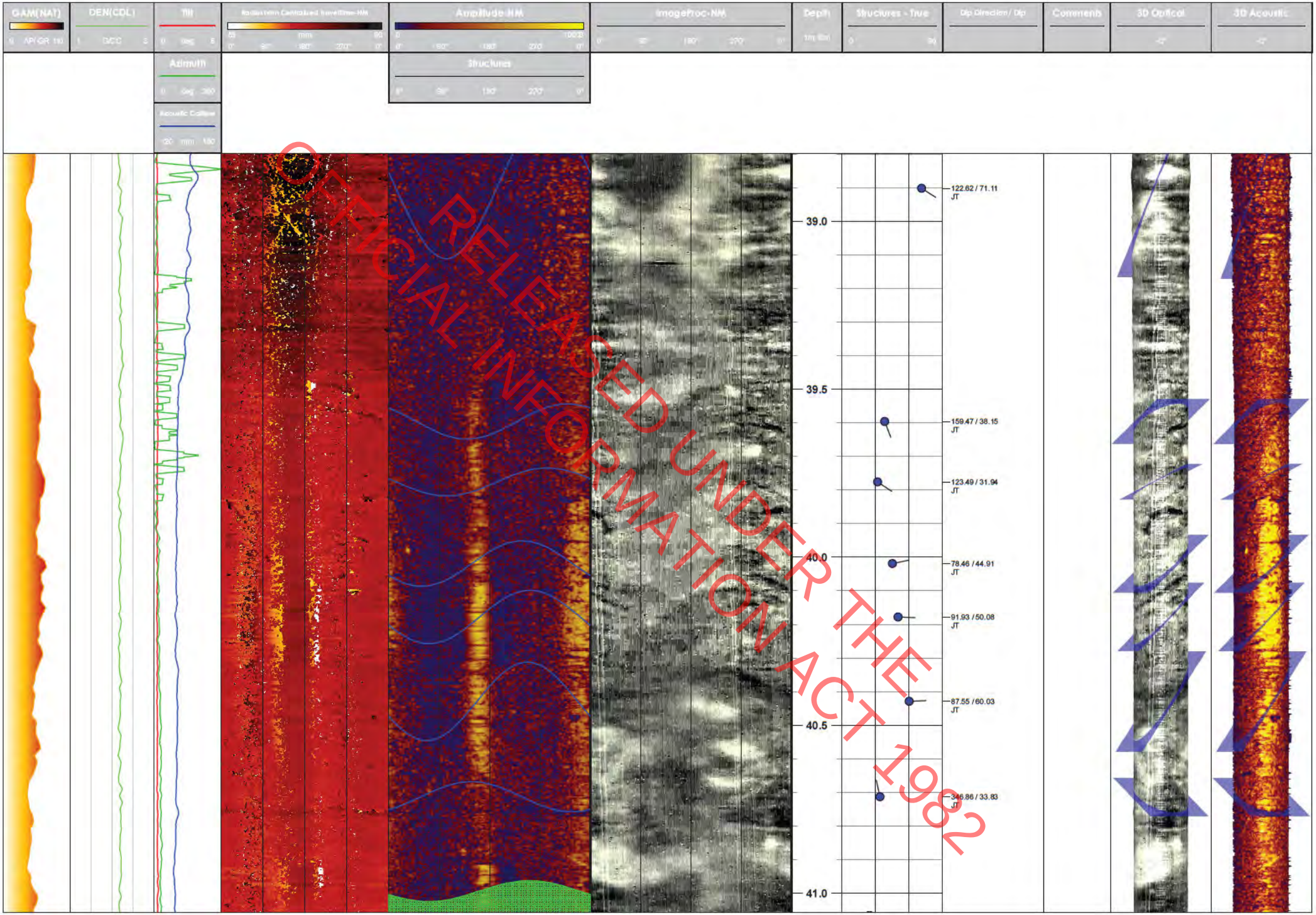

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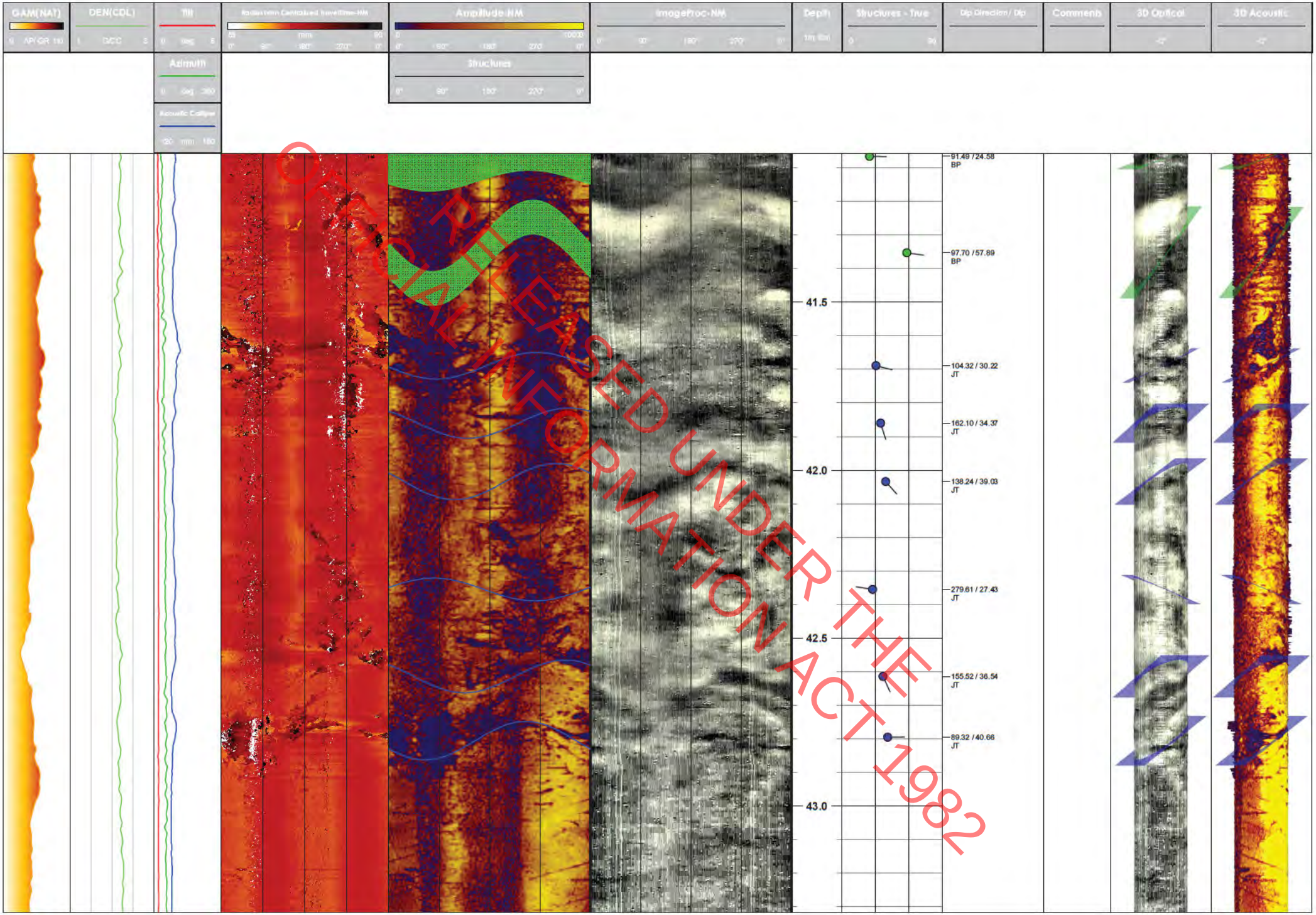

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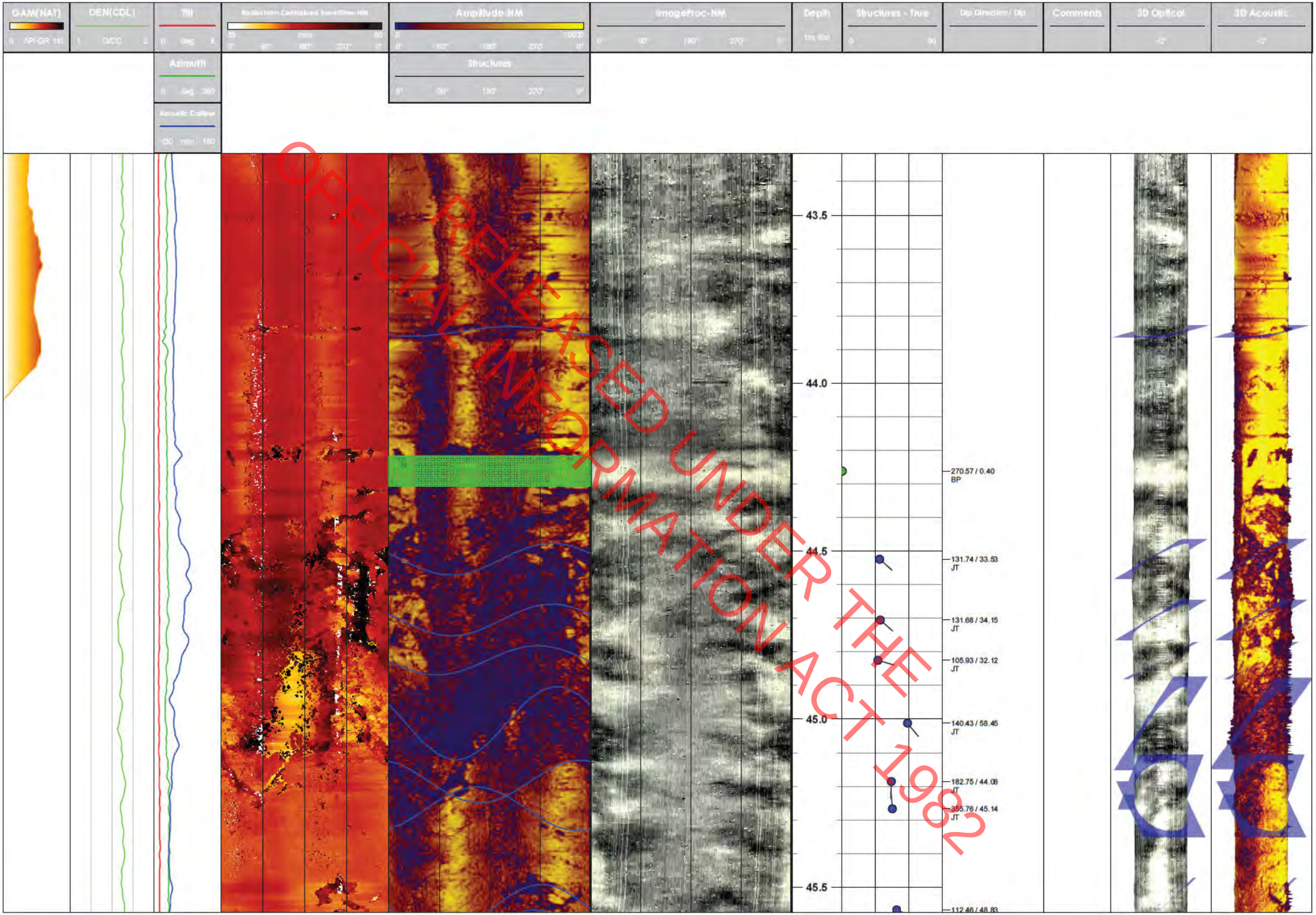

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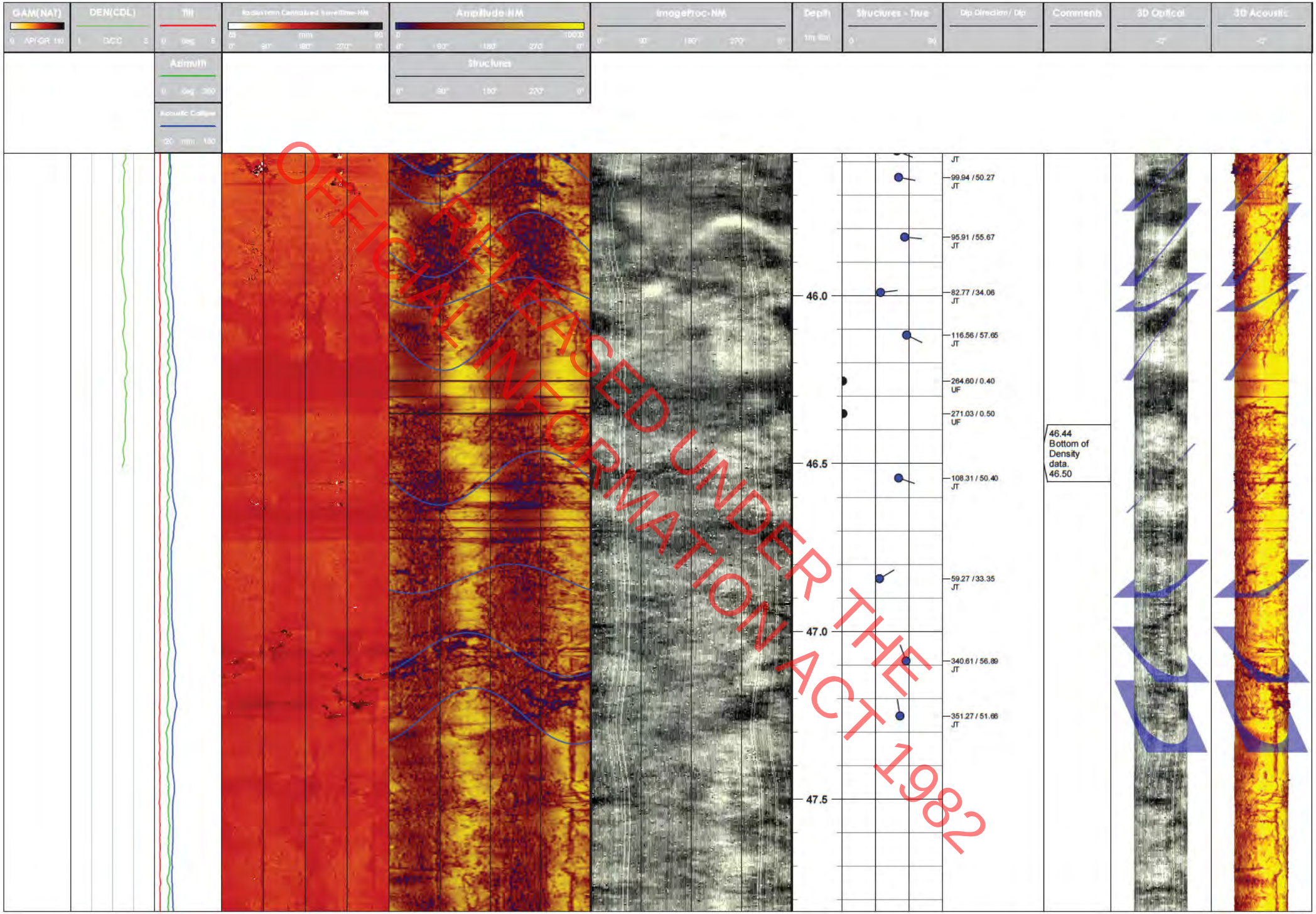

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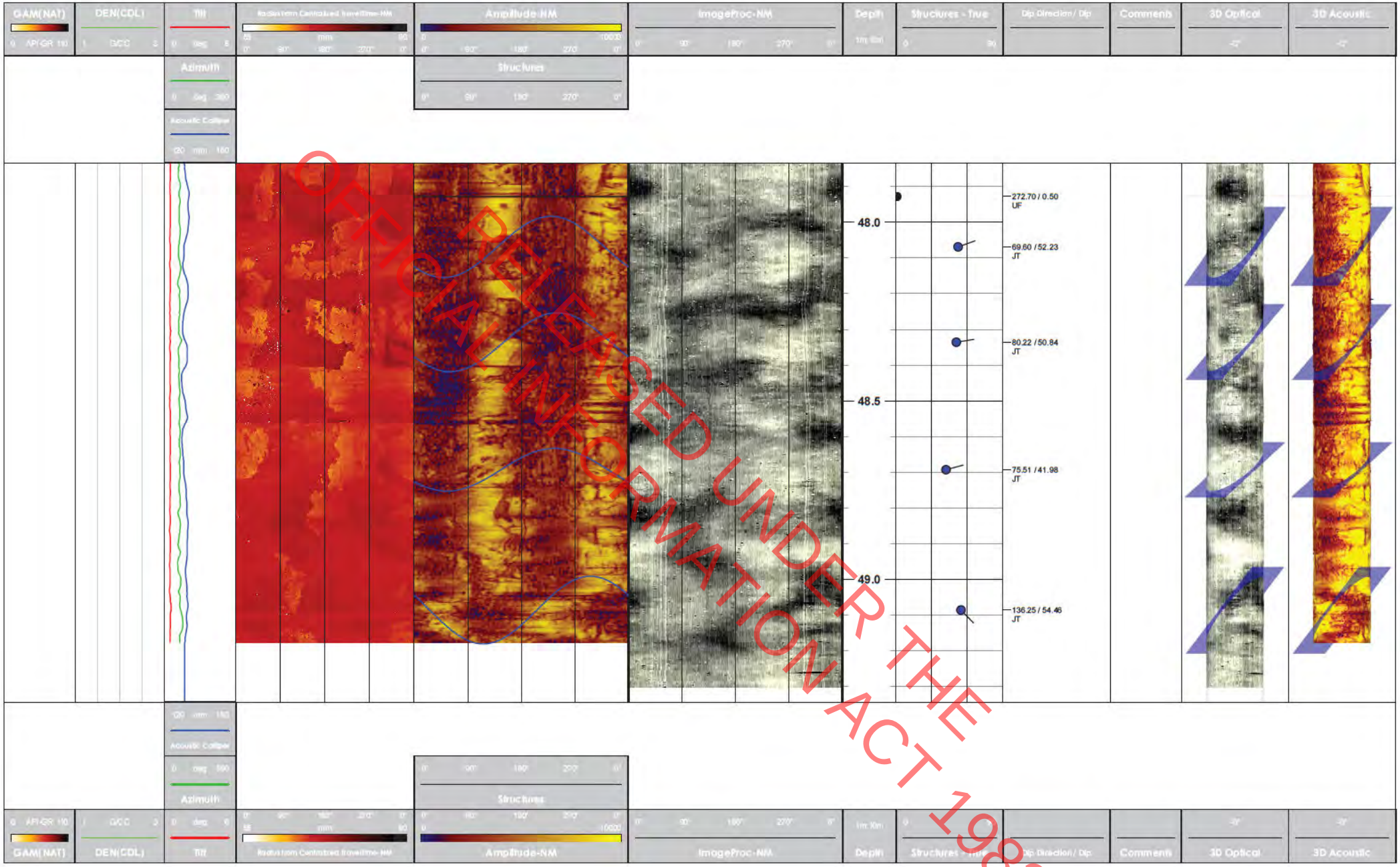

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RDCL

PO Box 28057
308 Queen's Street East
Hastings 4122
New Zealand

Ph: +64 6 8771652
Fax: +64 6 8775015
Email: info@rdcl.co.nz

Basic Information:

Well Name:	BH1207
Company:	Drill Force Ltd
Run No:	4 & 5
Tool Type(s):	QL40-FWSS Full Wave Form Sonic 9239 Compensated Density Geovista P&S Suspension Logger
Service Company:	RDCL
Operator:	K Koria
Witness:	H Soma
Date Logged:	27/02/2023
Field:	Auckland Light Rail
State / Province:	Auckland
Country:	New Zealand

Location Description:

1 Cambourne Road

Drillhole Information:

Bit Size:	PQ		
Log interval from:	1.50	Log interval to:	37.69
Depth Driller:	40.50	Depth Logger:	38.61 (Calliper)
Fluid Type:	Water	Fluid Level:	3.19 (Acoustic)
Northing:	1755054.380	Easting:	5916998.488
Elevation:	N/A	Projection:	NZTM
Hole Azimuth:	Vertical	Hole Inclination:	>-86.9°
Magnetic Declination:	+20° 8' East	Magnetic Inclination:	62° 49'
Casing Size:	No Casing	Casing Depth:	No Casing

Printing Information:

Print Type:	Paginated	Log Version:	Final
Depth Unit:	Metres	Scale Ratio:	1:25

Comments:

1. Coordinates taken from Google Earth and are approximate.
2. No S Wave picks from suspension logger between 8.0 -9.0 m, 16.0 - 22.0 m, 24.0 - 26. 0 m and 29.0 -30.0 m due to noisy data.
3. Density run stopped at 10.91 m due to tool hang up. Assumed density values used above this depth.
4. PS Suspension Logger started from 34.00 m due to length of tool.

Log Notes:

The elastic moduli and engineering parameters were calculated from Full Wave Form Sonic Tool Vp and Vs measurements and CCS tool density measurements. As such the logs should be considered in-situ, small strain and bulk measurements. These measurements may differ from laboratory testing for these reasons.

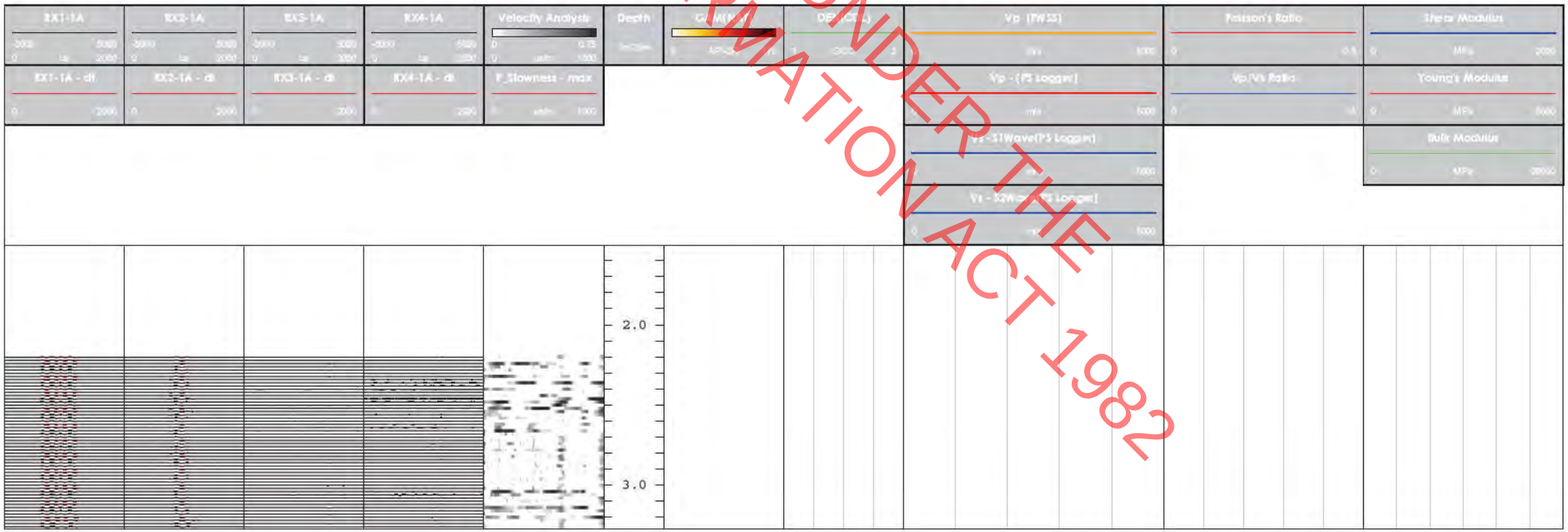
Log Calculations:

SI unit calculations:
Shear Modulus (G) = dVs²
Bulk Modulus (K) = 1/3*(E/(1-2*PR))
Young's Modulus (E) = 2G(1+PR)
Poisson's Ratio (PR) = 2-(Vp/Vs)²/2-2(Vp/Vs)²

Where:
Vp = P-wave seismic velocity
Vs = S-wave seismic velocity
d = Density

Log Nomenclature:

Velocity Analysis = Output of semblance processing
S_Slowness = Shear wave slowness from semblane
Vp = P-wave velocity
Vs = Shear wave velocity from S-Slowness
DEN(CDL) = Compensated Density
Shear Modulus = Shear Modulus (G0)
Bulk Modulus = Bulk Modulus (K)
Young's Modulus = Young's Modulus (E)
Poisson's Ratio = Poisson's Ratio (PR)
Vp/Vs = P-wave S-wave ratio
RX#-1A = Wiggle window of sensor #
RX#-1A - dt = Picked first arrival time for sensor #



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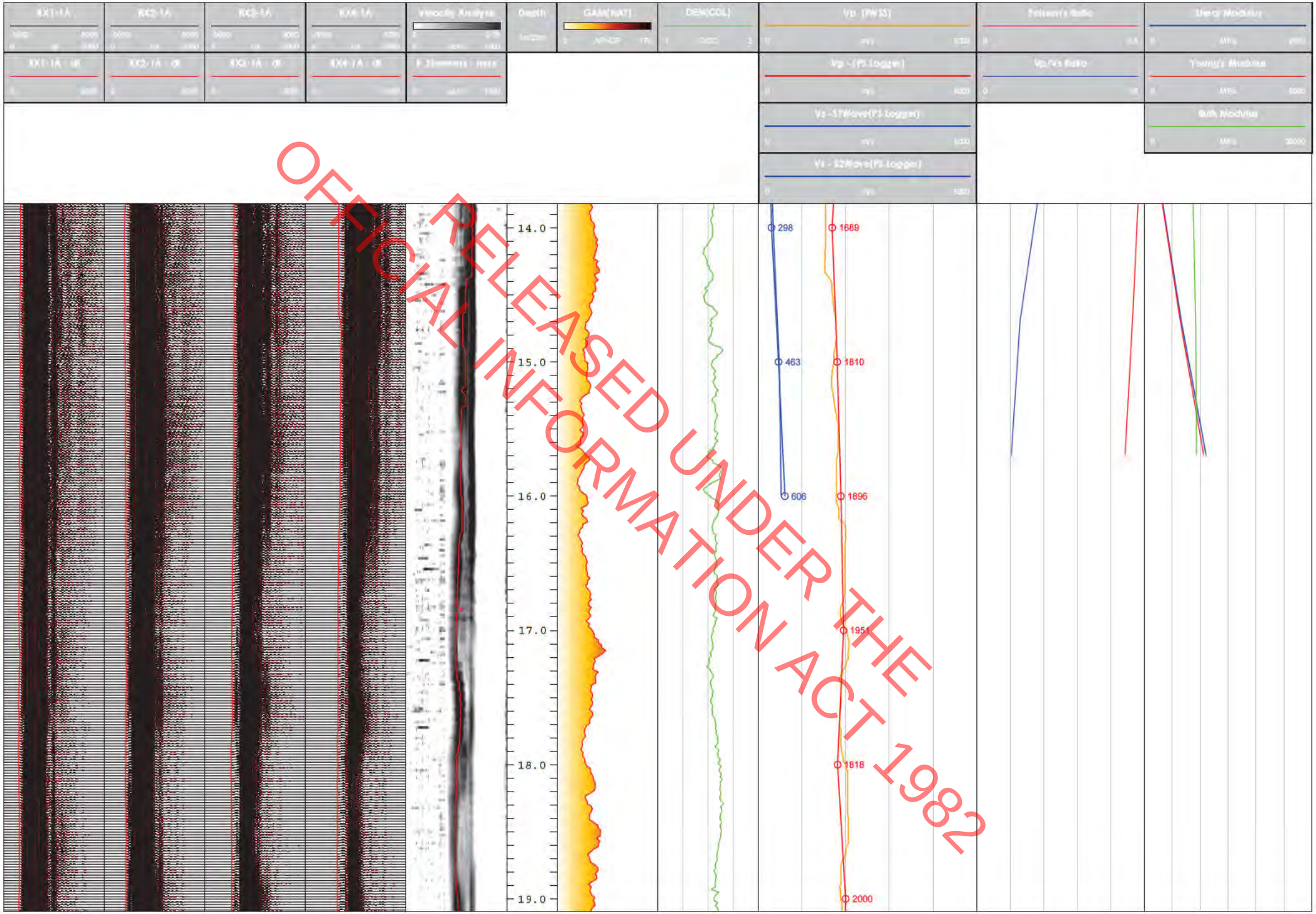

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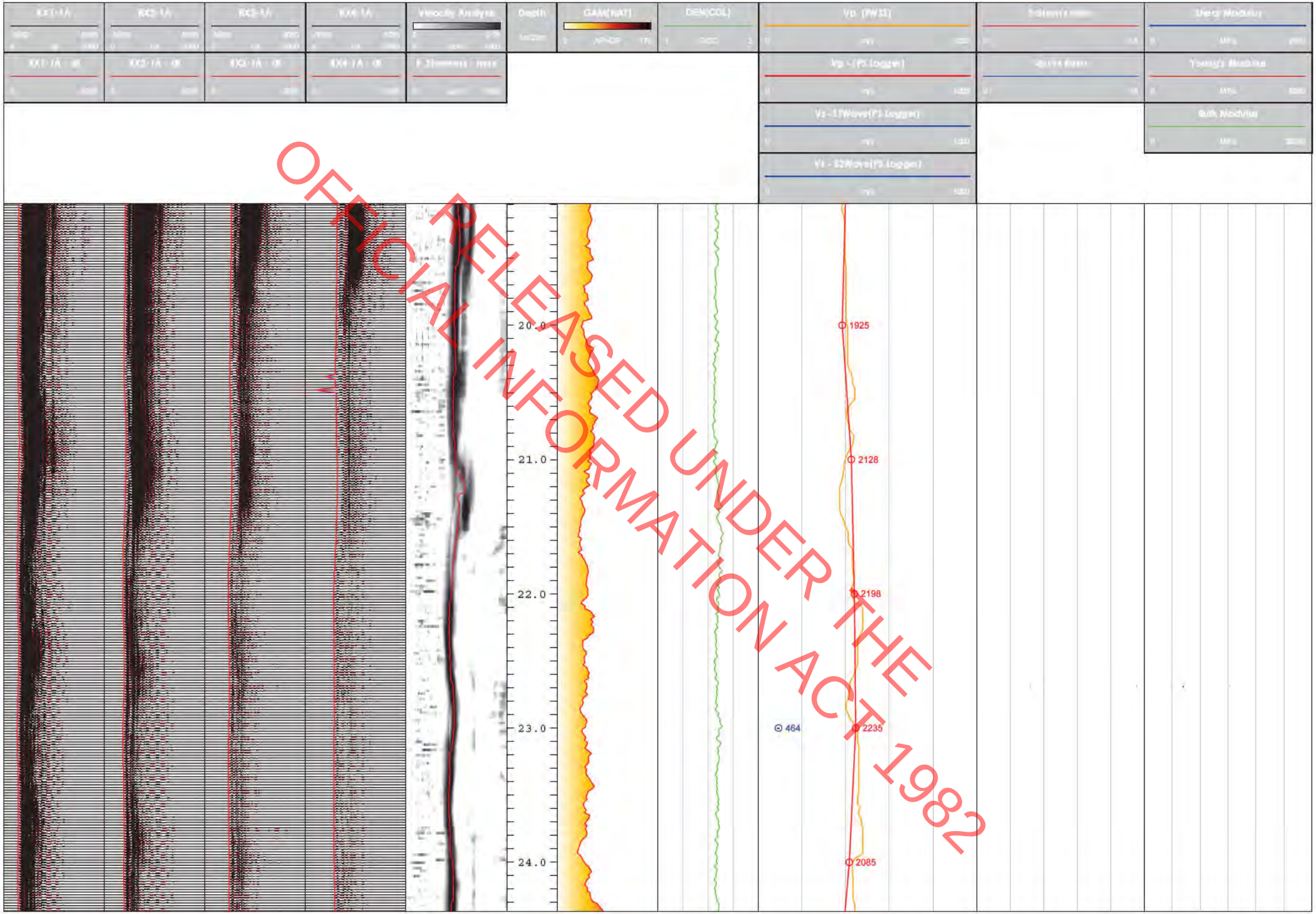

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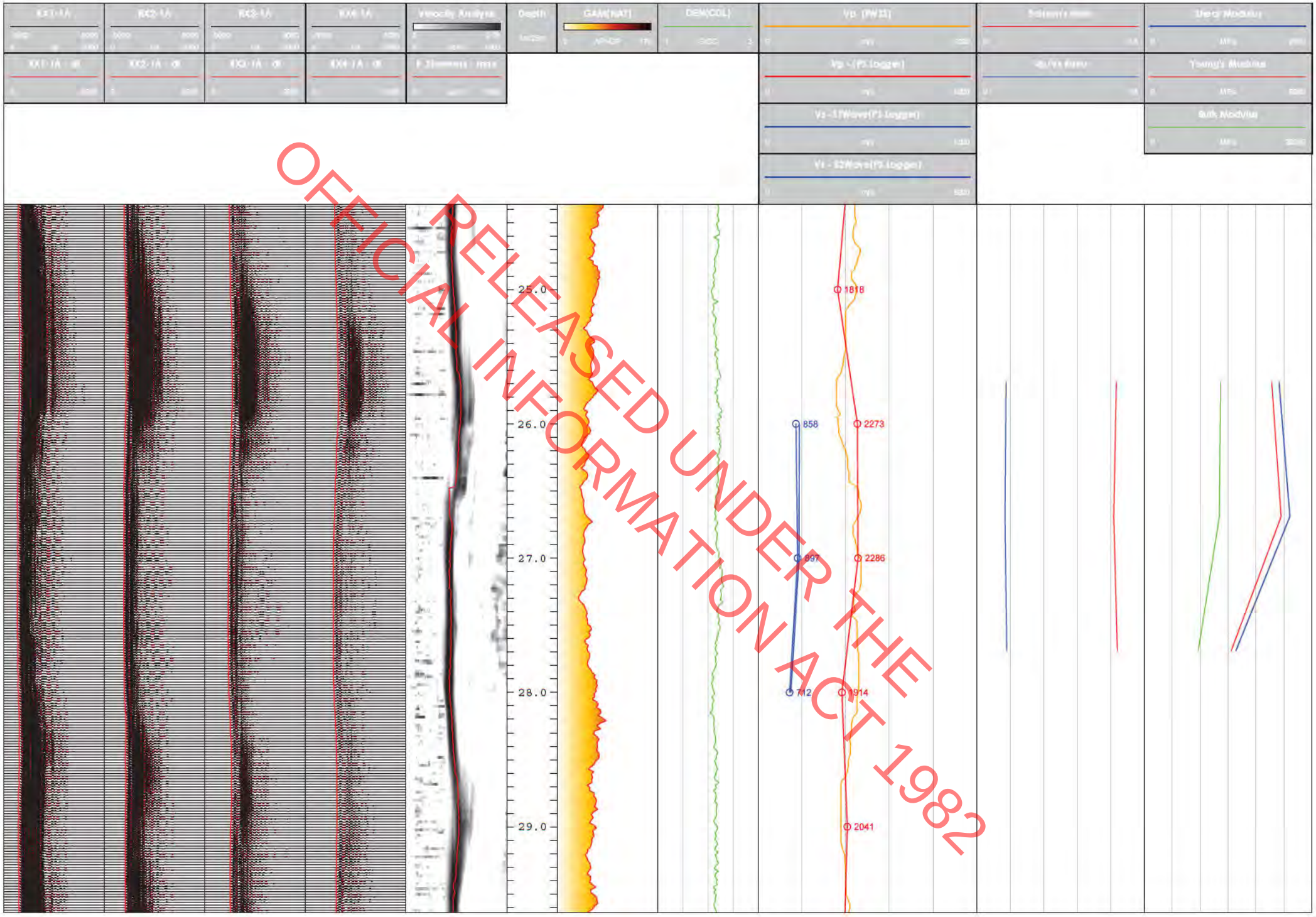

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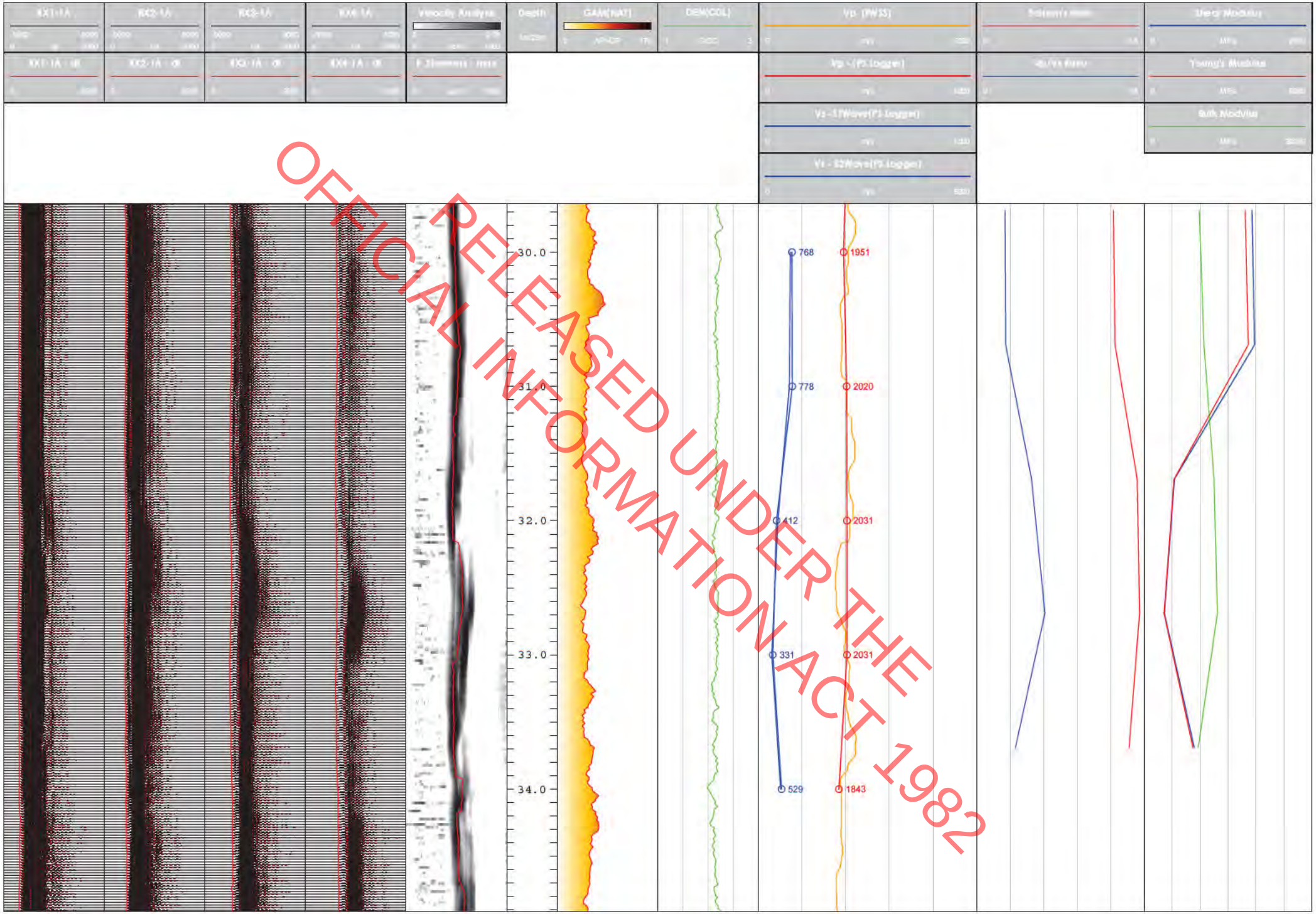

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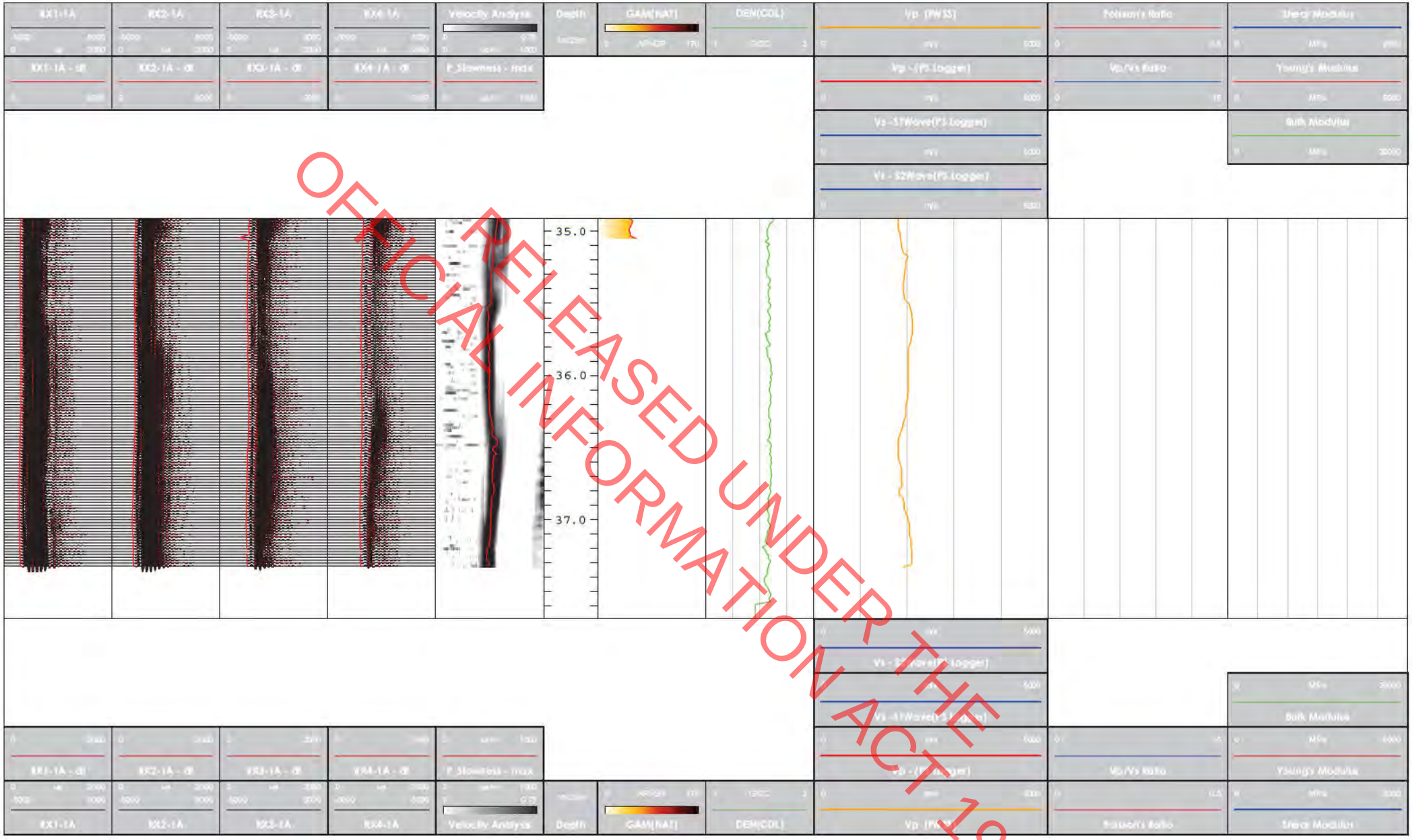

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RDCL

Unit A3, 269a Mt Smart Road
Onehunga
Auckland, 1061
New Zealand

Ph: +64 6 8771652
Fax: +64 6 8775015
Email: info@rdcl.co.nz
www.rdcl.co.nz

Basic Information:

Drill hole ID:	BH1207
Client:	Drill Force Ltd
Run Number(s):	1, 2 & 3
Tool Type(s):	ABI40-2G Acoustic Televiewer OBI40-2G Optical Televiewer CAL40 Mech 3-arm Calliper
Service Company:	RDCL
Operator:	K Koria/ H Soma
Date Logged:	27/02/2023
Field:	Auckland Light Rail
State / Province:	Auckland
Country:	New Zealand

Location Description:

1 Cambourne Road

Drillhole Information:

Log interval from (m):	0.65	Log interval to (m):	38.61
Depth Driller (m):	40.50	Depth Logger (m):	38.61 (Calliper)
Fluid Type:	Water	Fluid Level (m):	3.19 (Acoustic)
Easting:	5916998.488	Northing:	1755054.380
Elevation:	N/A	Coord Ref System:	TBC
Hole Azimuth:	Vertical	Hole Inclination:	>-86.9°
Magnetic Declination:	+20° 8' East	Magnetic Inclination:	62° 49'
Drill Company:	Drill Force Ltd		

Printing Information:

Depth Unit:	Metres	Log Scale:	1:10	Log Version:	Final
Processed:	H Soma			Log Reviewer:	K Koria

Bit Size Record:

Size (mm):	From (m):	To (m):
##.#	##.#	##.#
##.#	##.#	##.#
##.#	##.#	##.#
##.#	##.#	##.#

Casing Record:

Type:	Size:	From (m):	To (m):
XX	##.#	##.#	##.#
XX	##.#	##.#	##.#
XX	##.#	##.#	##.#
XX	##.#	##.#	##.#

Structural Legend:

- BP - Bedding Plane
- BF - Bedding Fracture
- JT - Joint
- FR - Fracture
- FZ - Fractured Zone
- SH - Shear
- CZ - Crushed Zone
- IF - Infilled Zone
- DZ - Decomposed Zone
- UF - Unidentified Feature

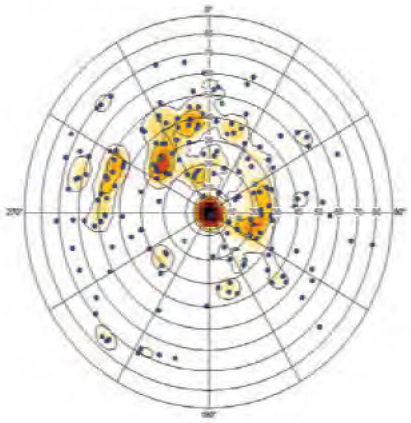
Log Nomenclature:

Azimuth = Tool azimuth from magnetic north
Tilt = Inclination from vertical
Acoustic Calliper = 360° average from travel time
Calliper from Cent = Calliper derived from travel time
Image-NM = Optical image oriented to magnetic north
Amplitude-NM = Acoustic amplitude (magnetic north)
Structures = Apparent Structures oriented to hole
Structures - True =Structures Oriented to true north
3D Optical = 3D representation of optical log
3D Acoustic = 3D representation of acoustic log

Comments:

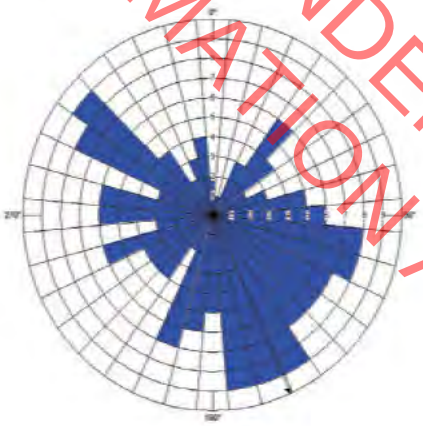
1. Structures - True are reported in dip direction and dip relative to grid north.
2. Optical data obscured below water line due to Turbid water conditions.
3. Coordinates taken from Google Earth and are approximate.

Stereoplot - Polar Projection Dip



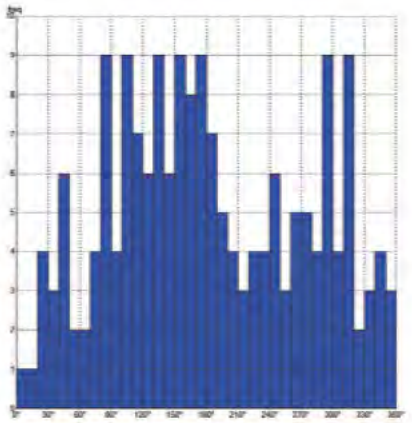
Schmidt Plot - Upper (Northern) Hemisphere - Structures - True
Depth: 0.65 m to 38.61 m

Rose Diagram - Azimuth



Depth: 0.65 m to 38.61 m

Histogram - Azimuth



Depth: 0.65 m to 38.61 m

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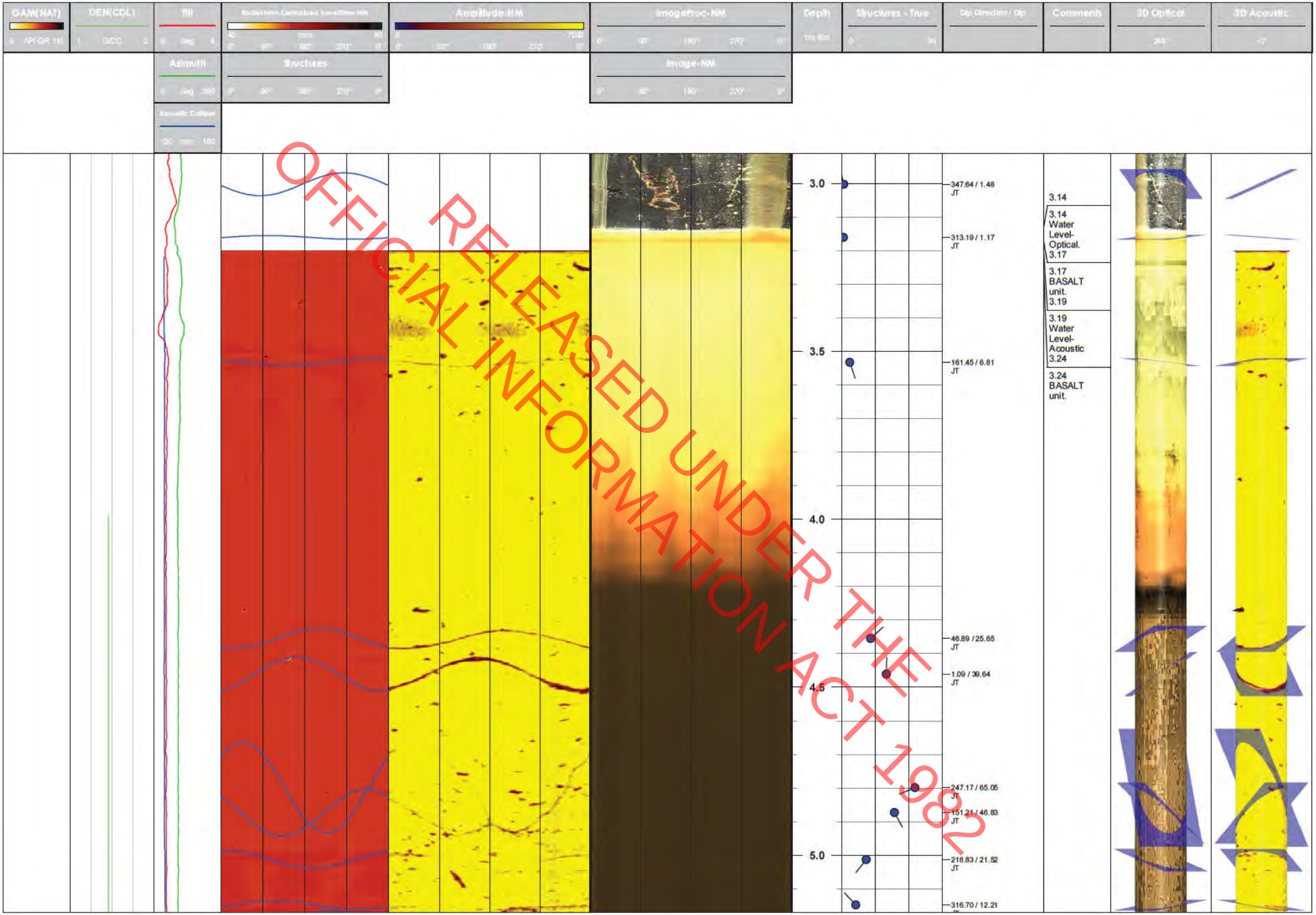

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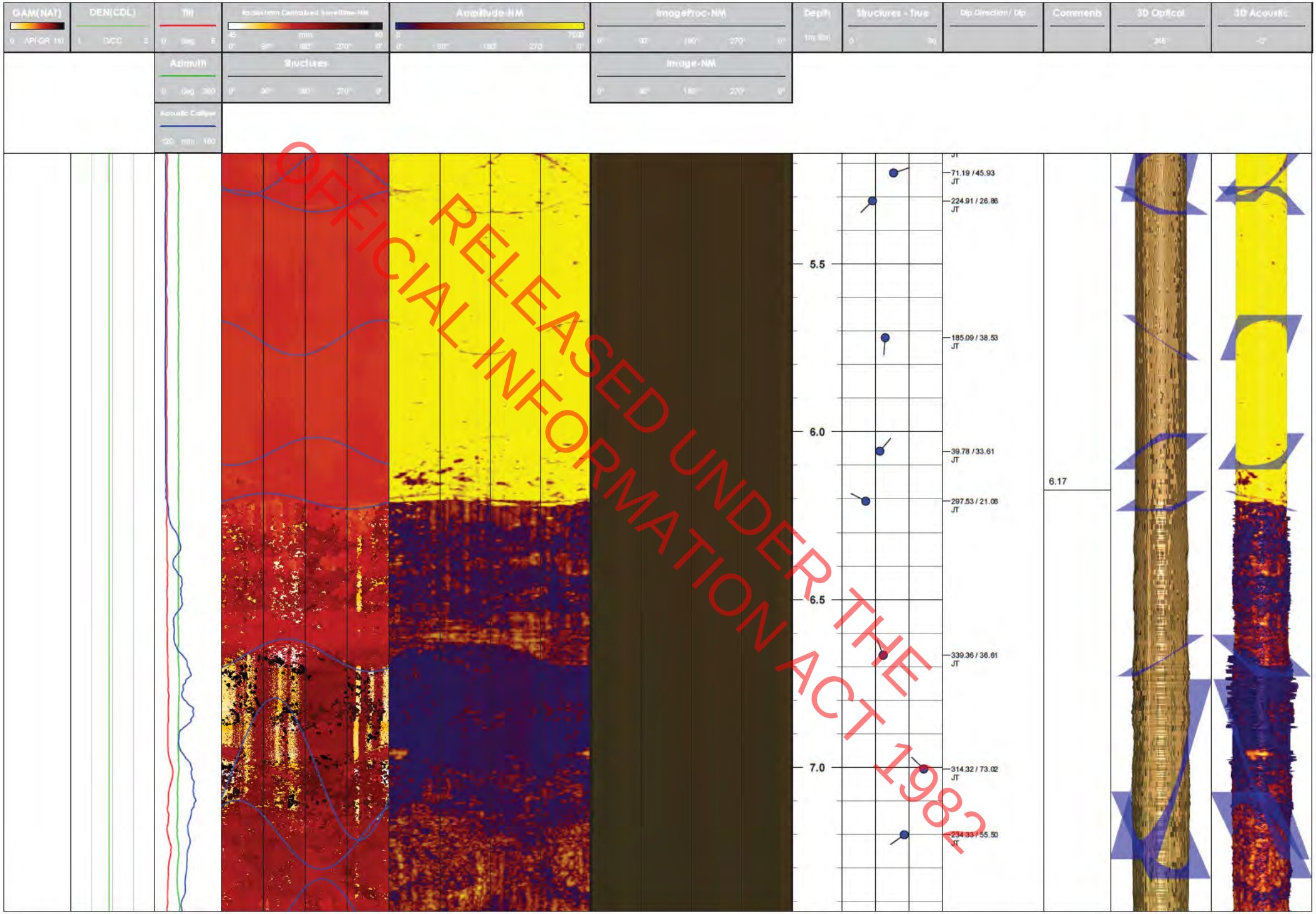
GAM(NAT)
DEN(CDL)
Tilt
Azimuth
Acoustic Caliper
Radial-Horn Corrected travelTime-NM
Amplitude-NM
Structures
ImageProc-NM
Image-NM
Depth
Structures - True
Dip Direction / Dip
Comments
3D Optical
3D Acoustic
71.19 / 45.93 JT
224.91 / 26.86 JT
185.09 / 38.53 JT
39.78 / 33.61 JT
297.53 / 21.05 JT
339.36 / 36.61 JT
314.32 / 73.02 JT
234.33 / 55.50 JT
6.17
5.5
6.0
6.5
7.0
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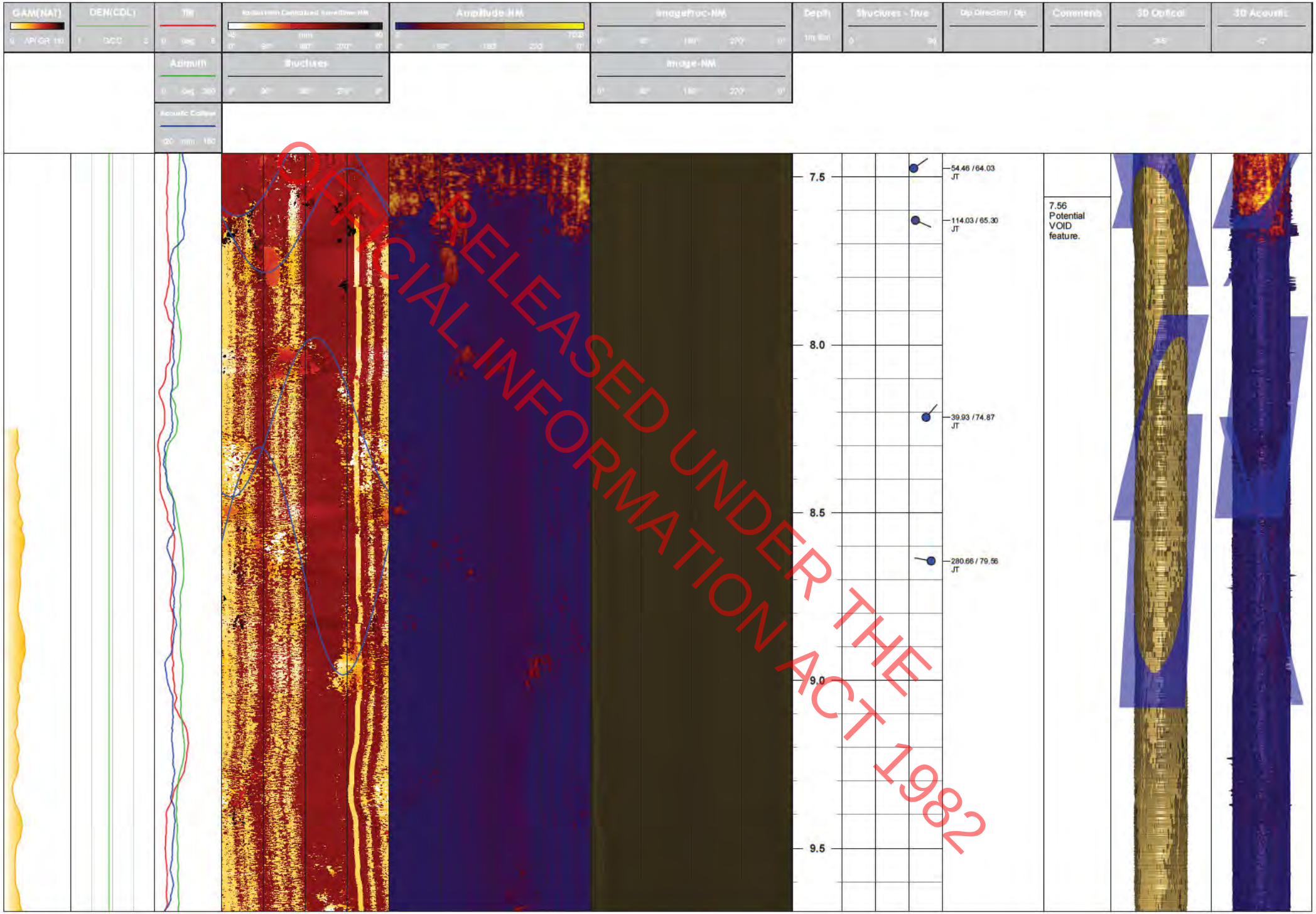

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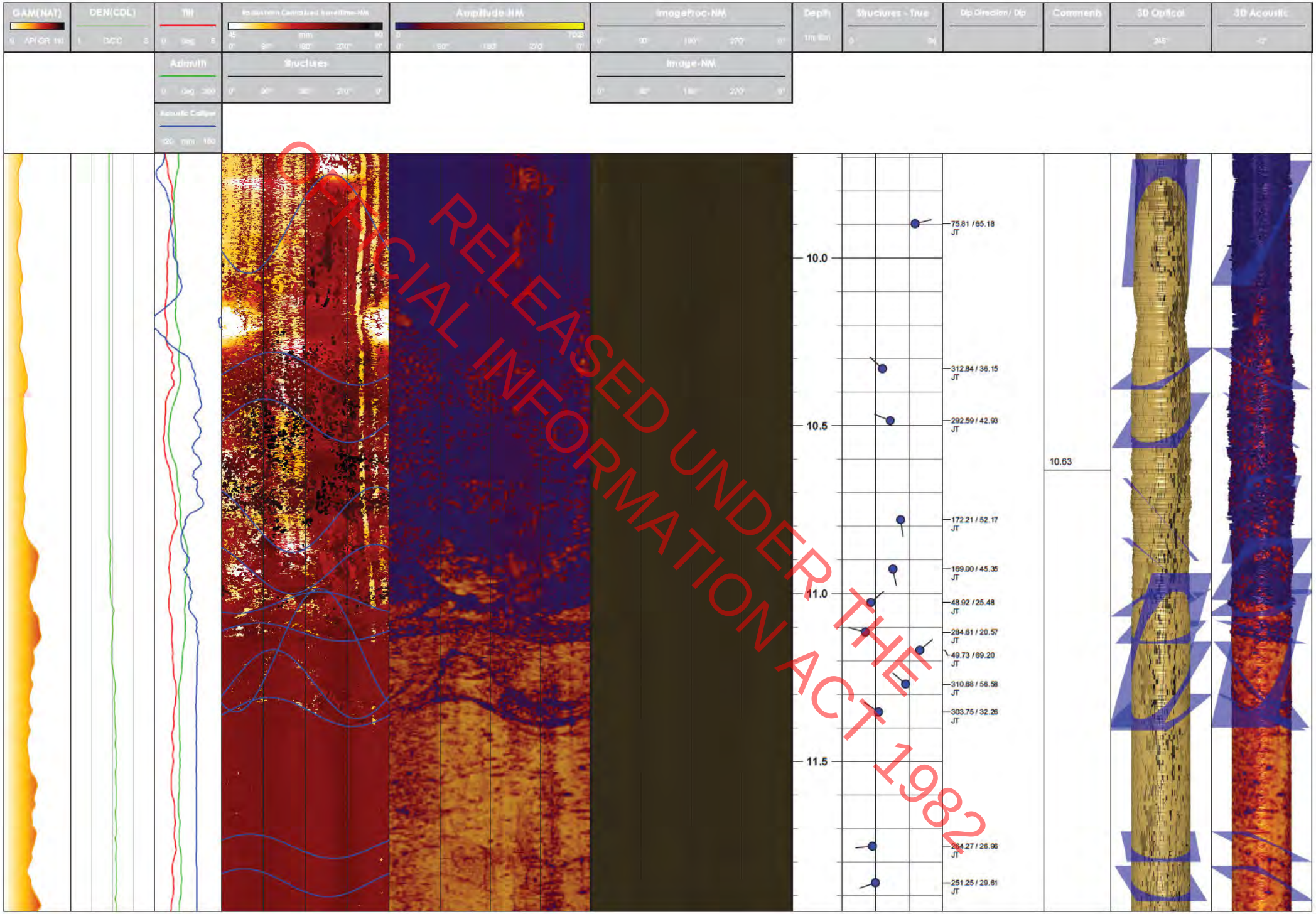

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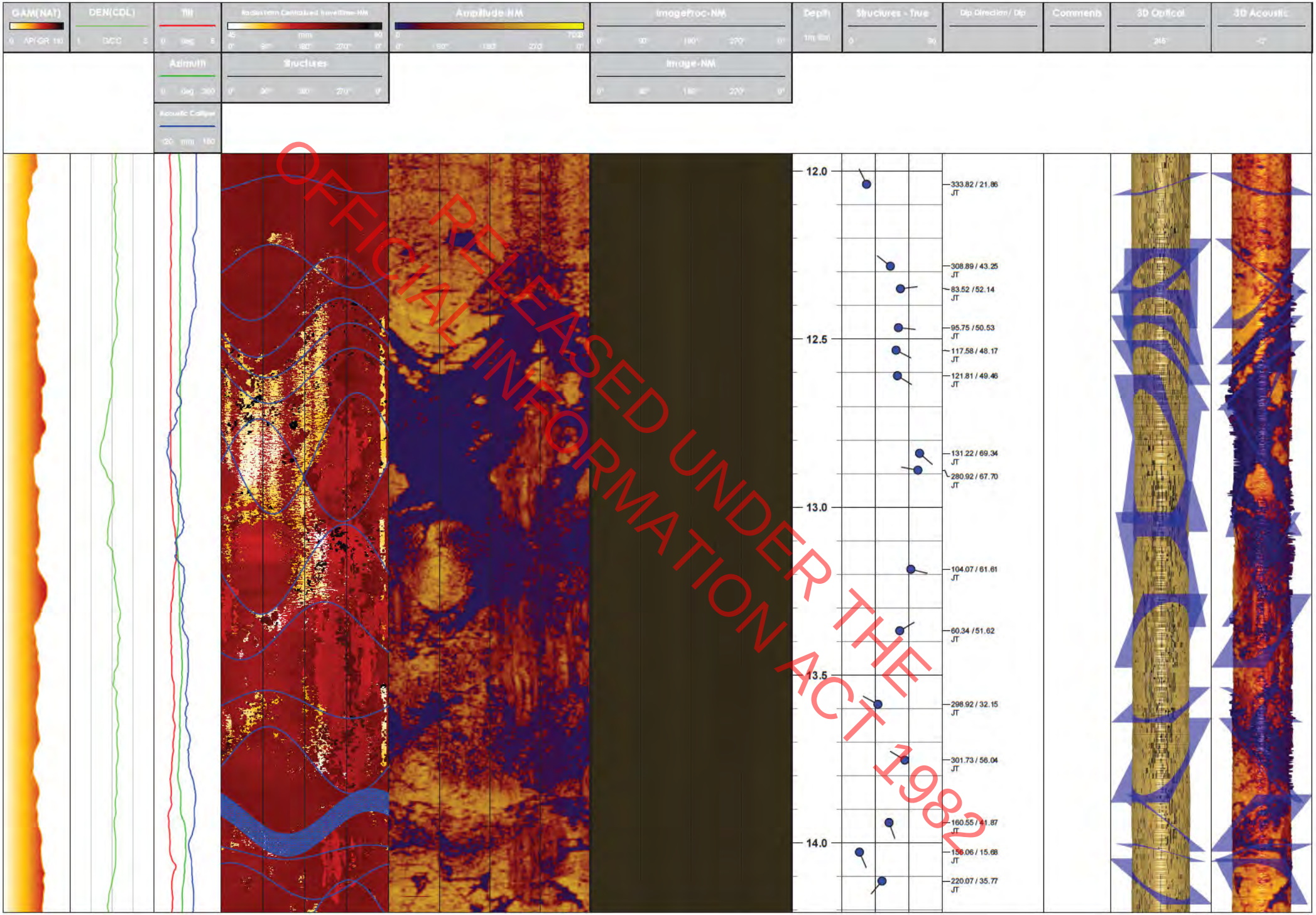

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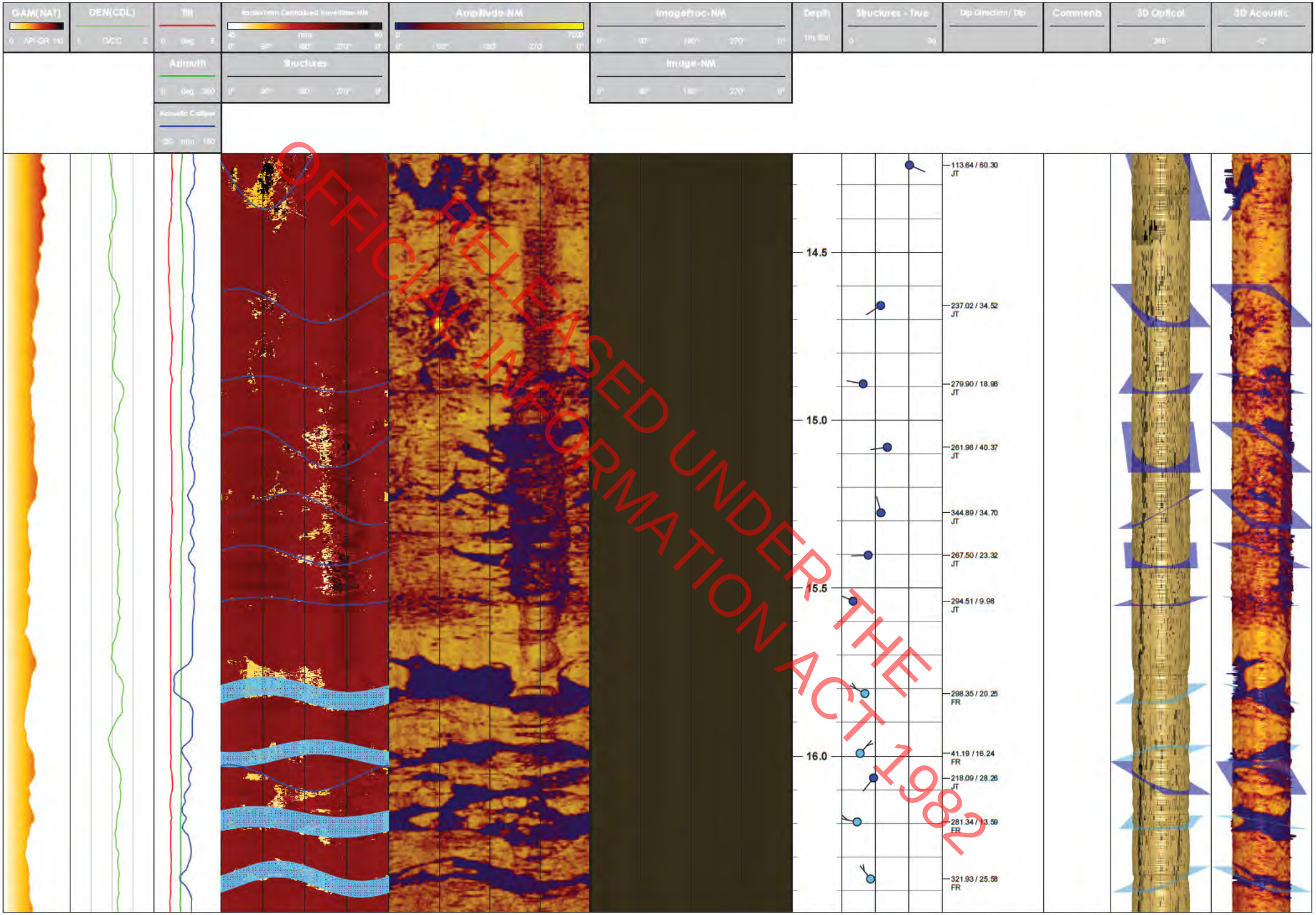

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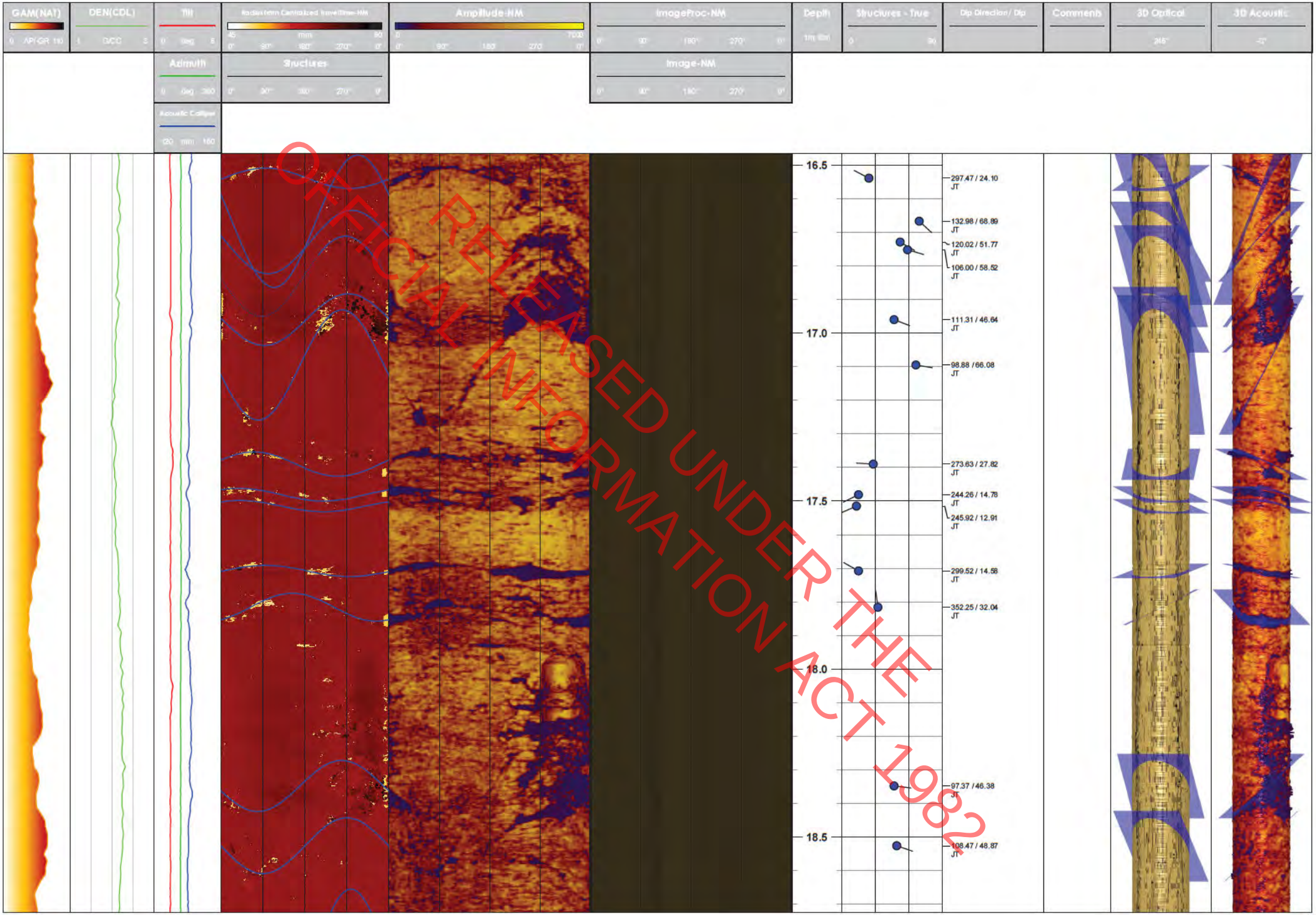

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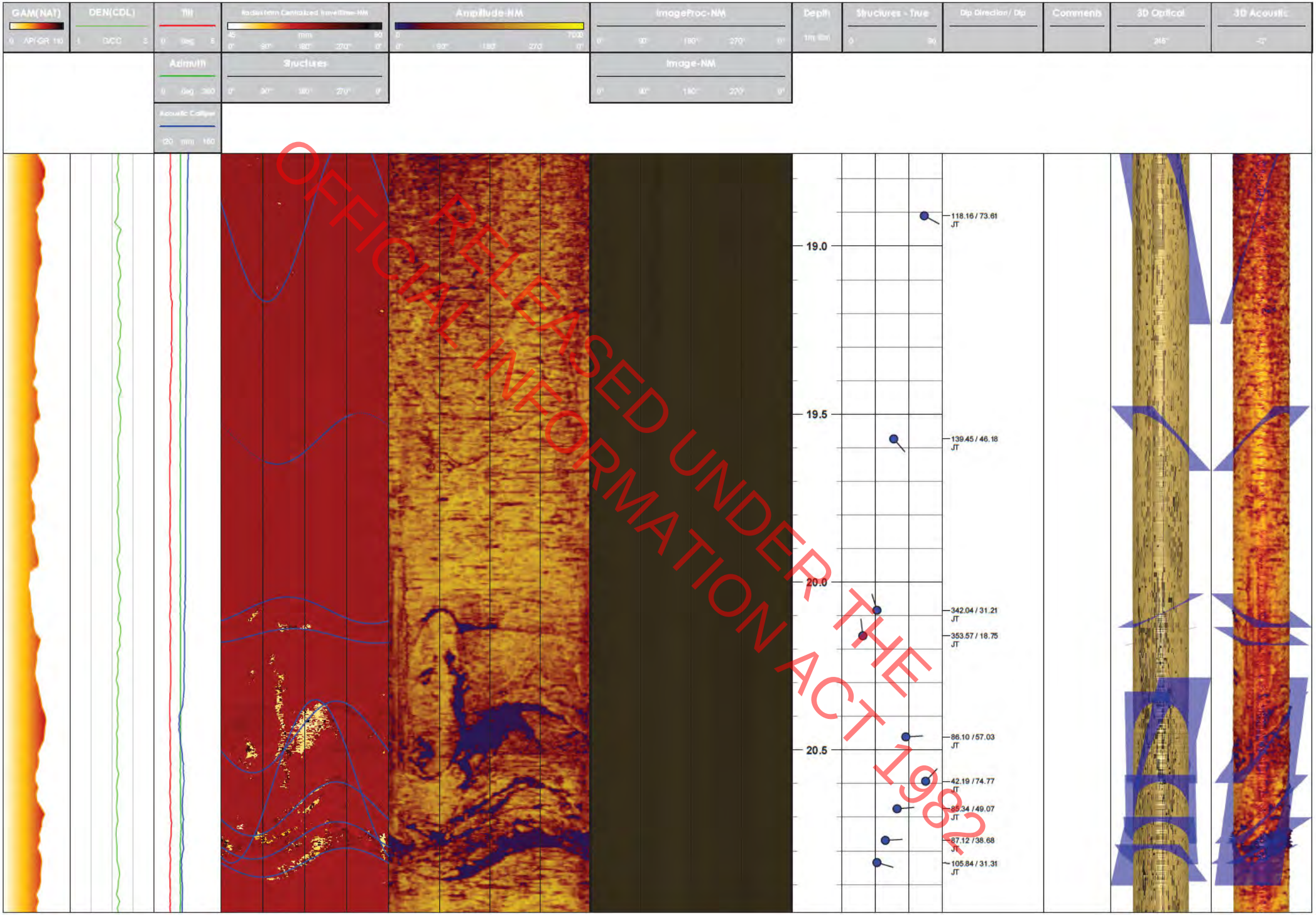

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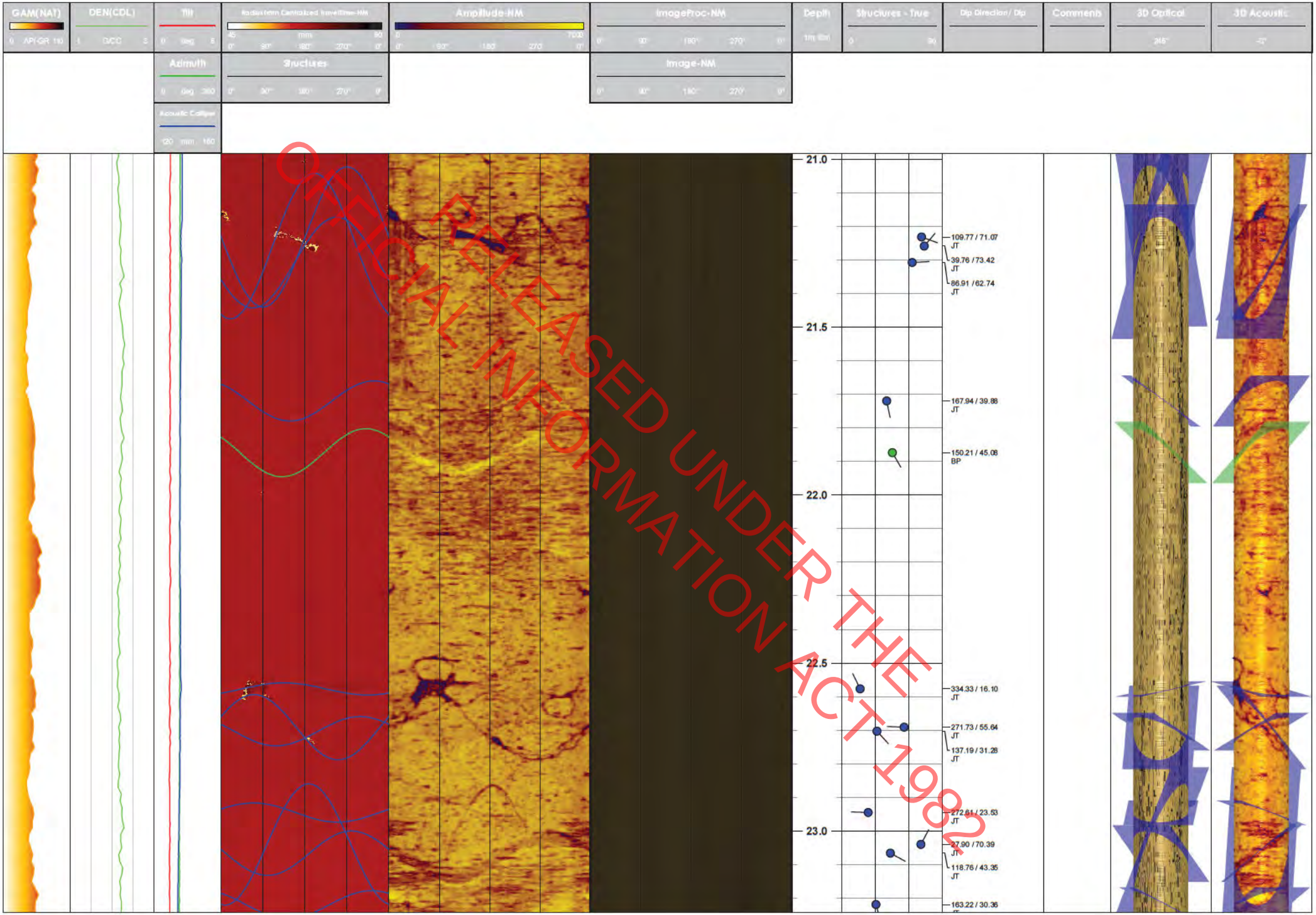

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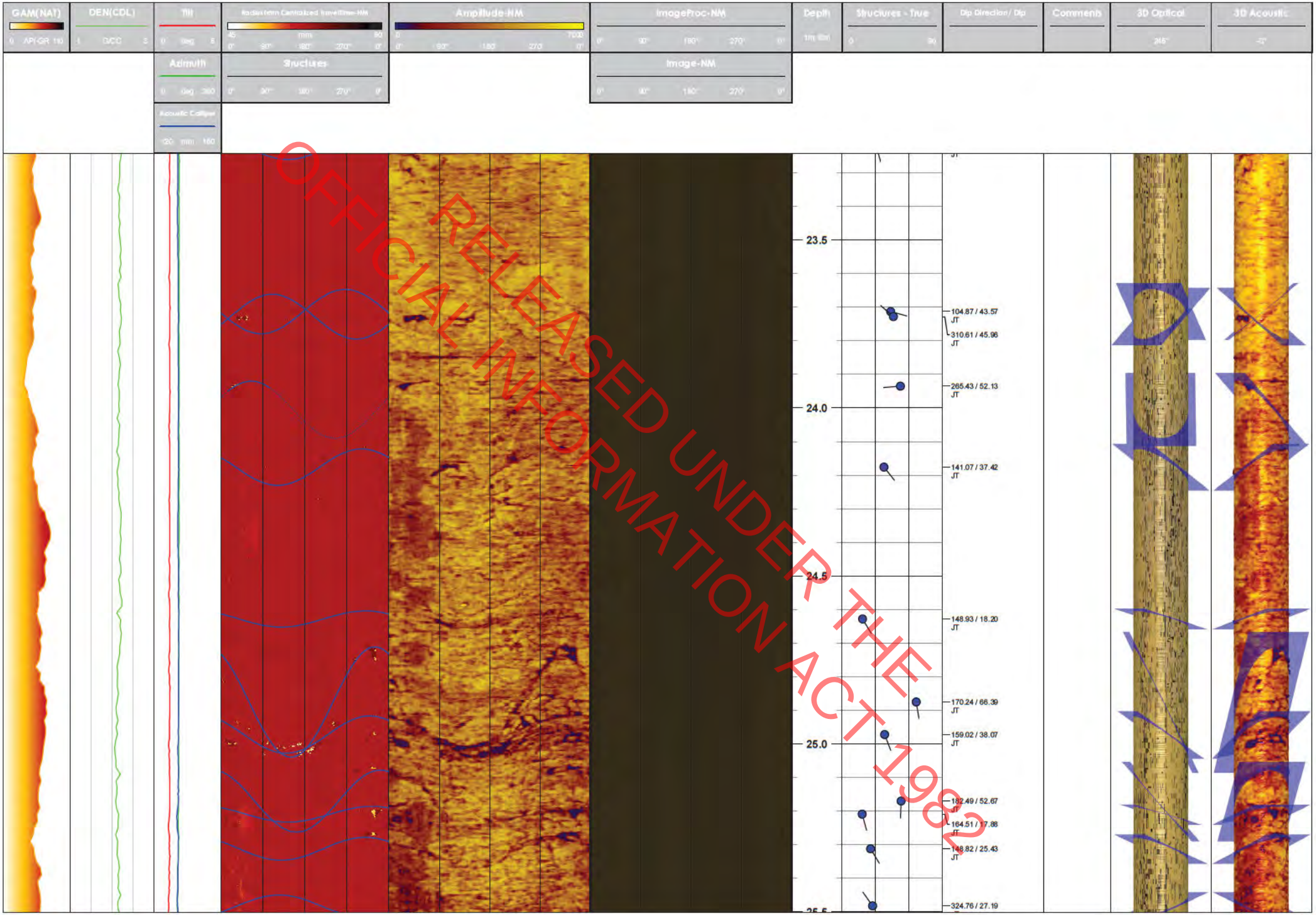

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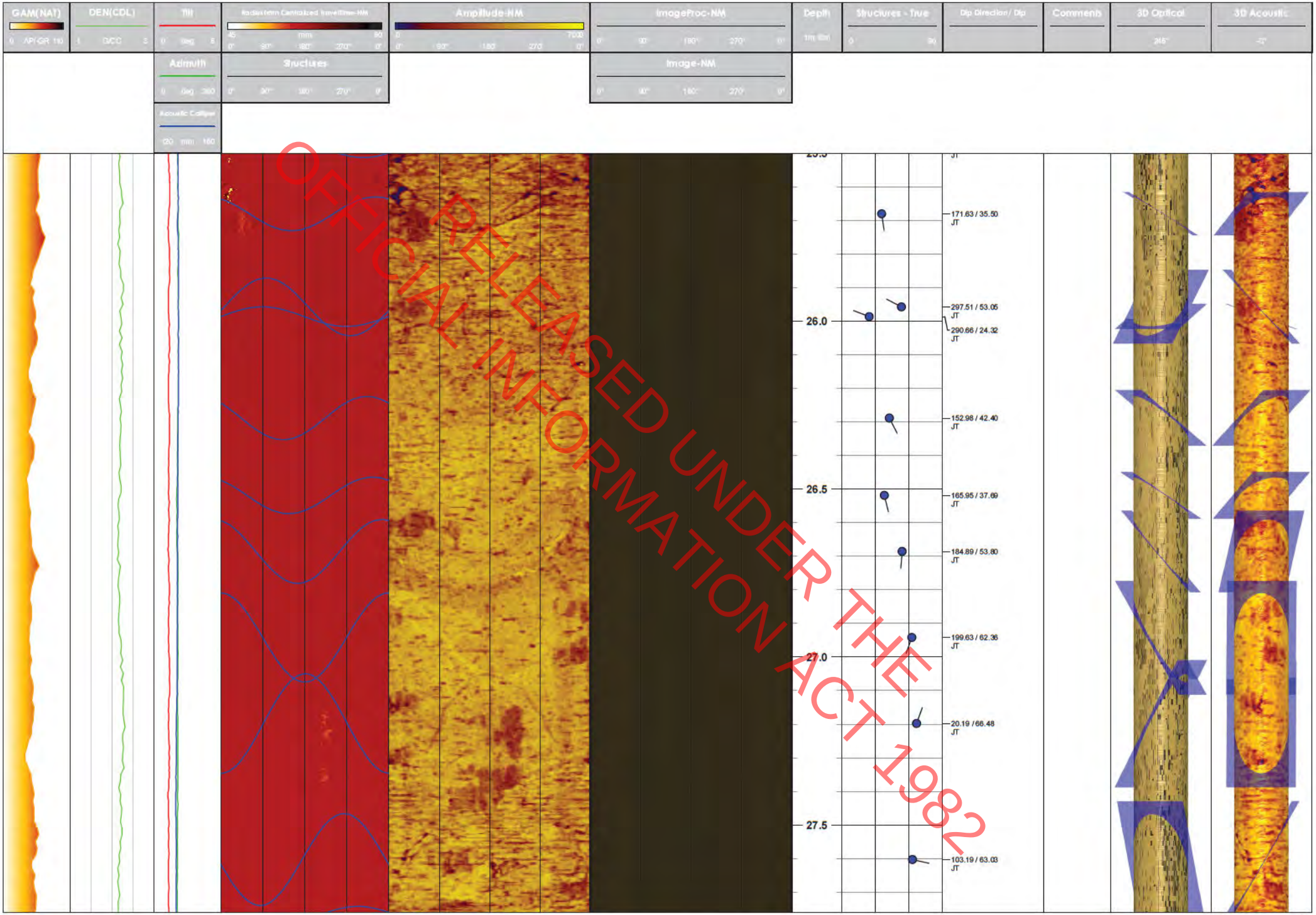

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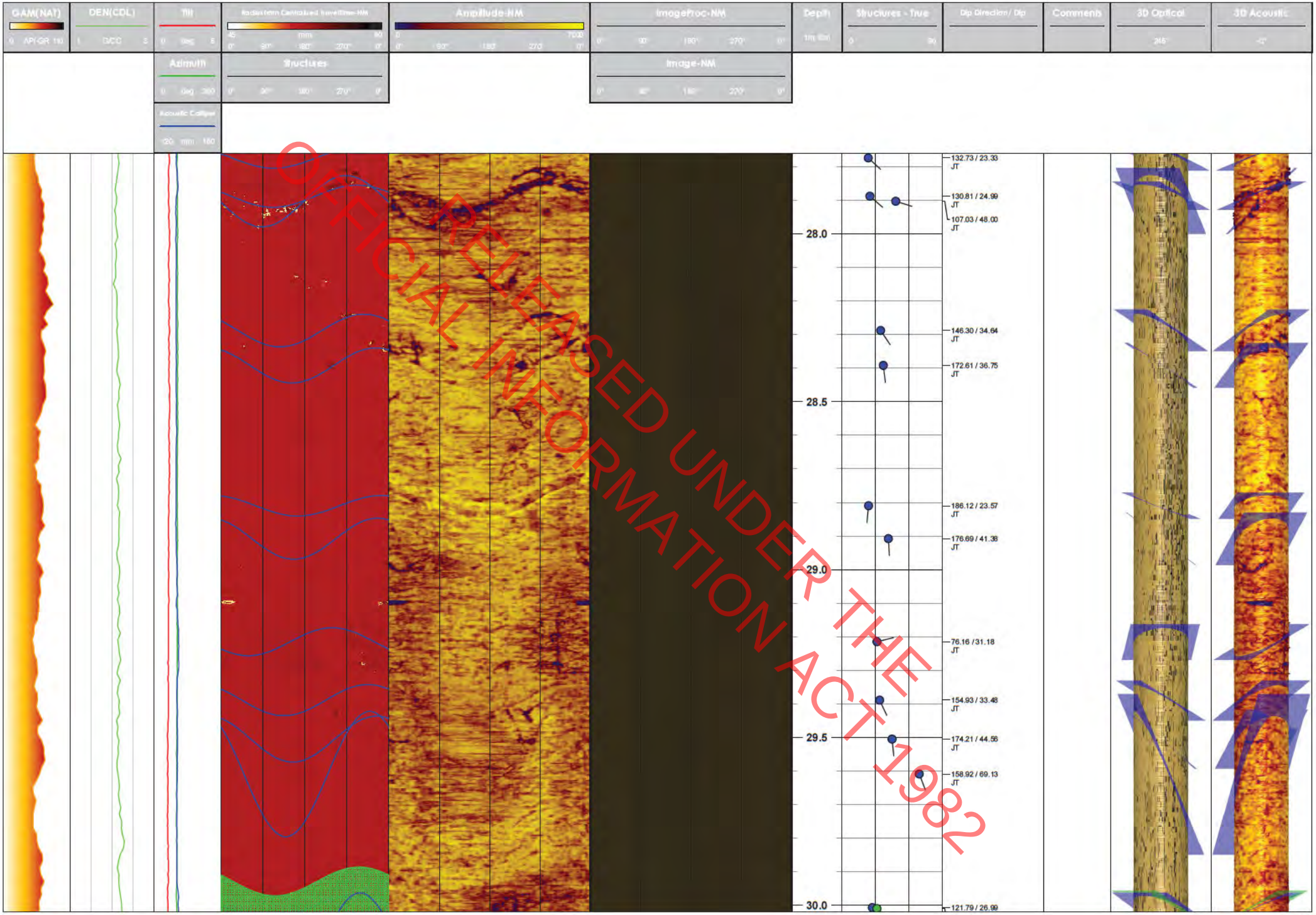

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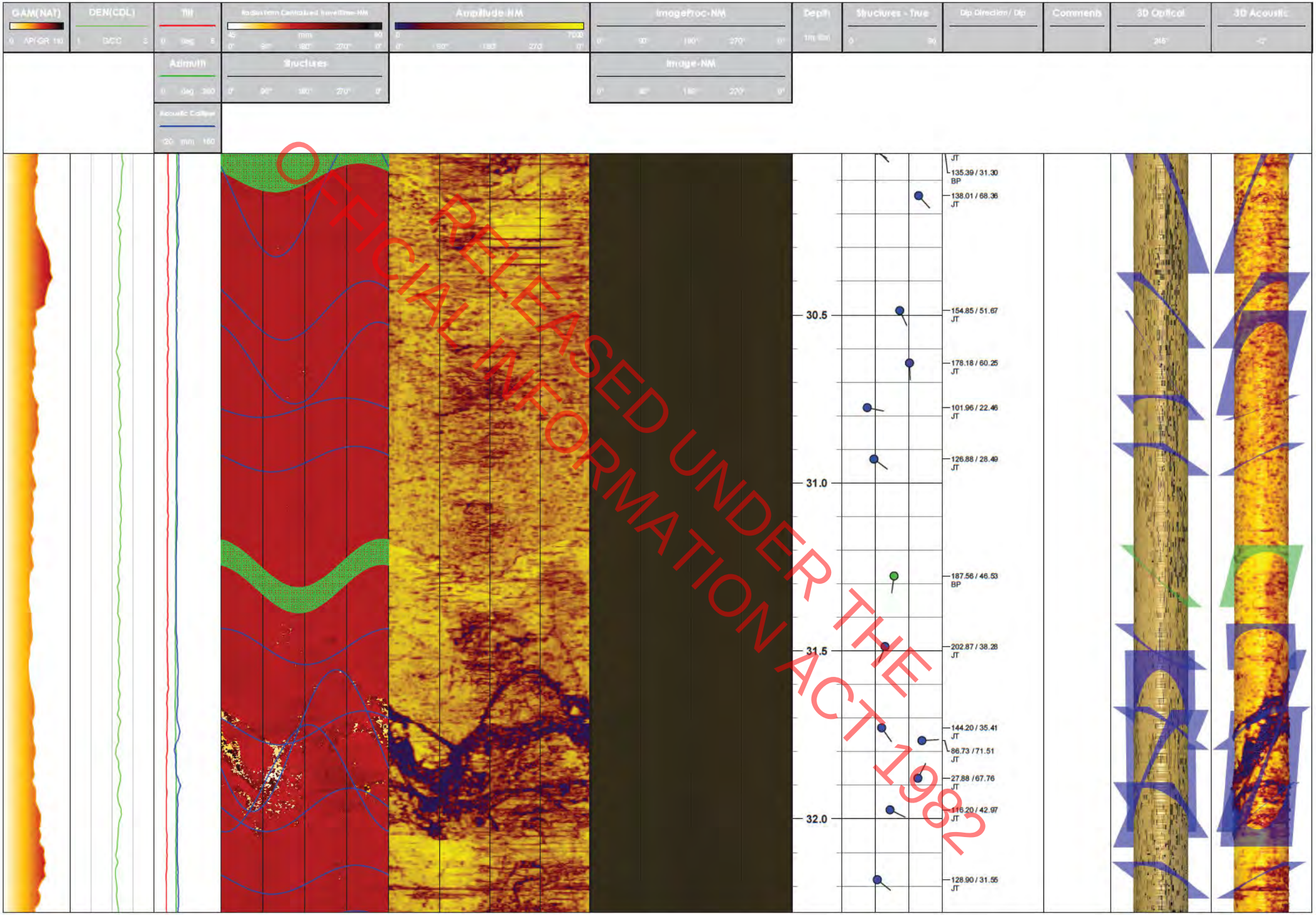

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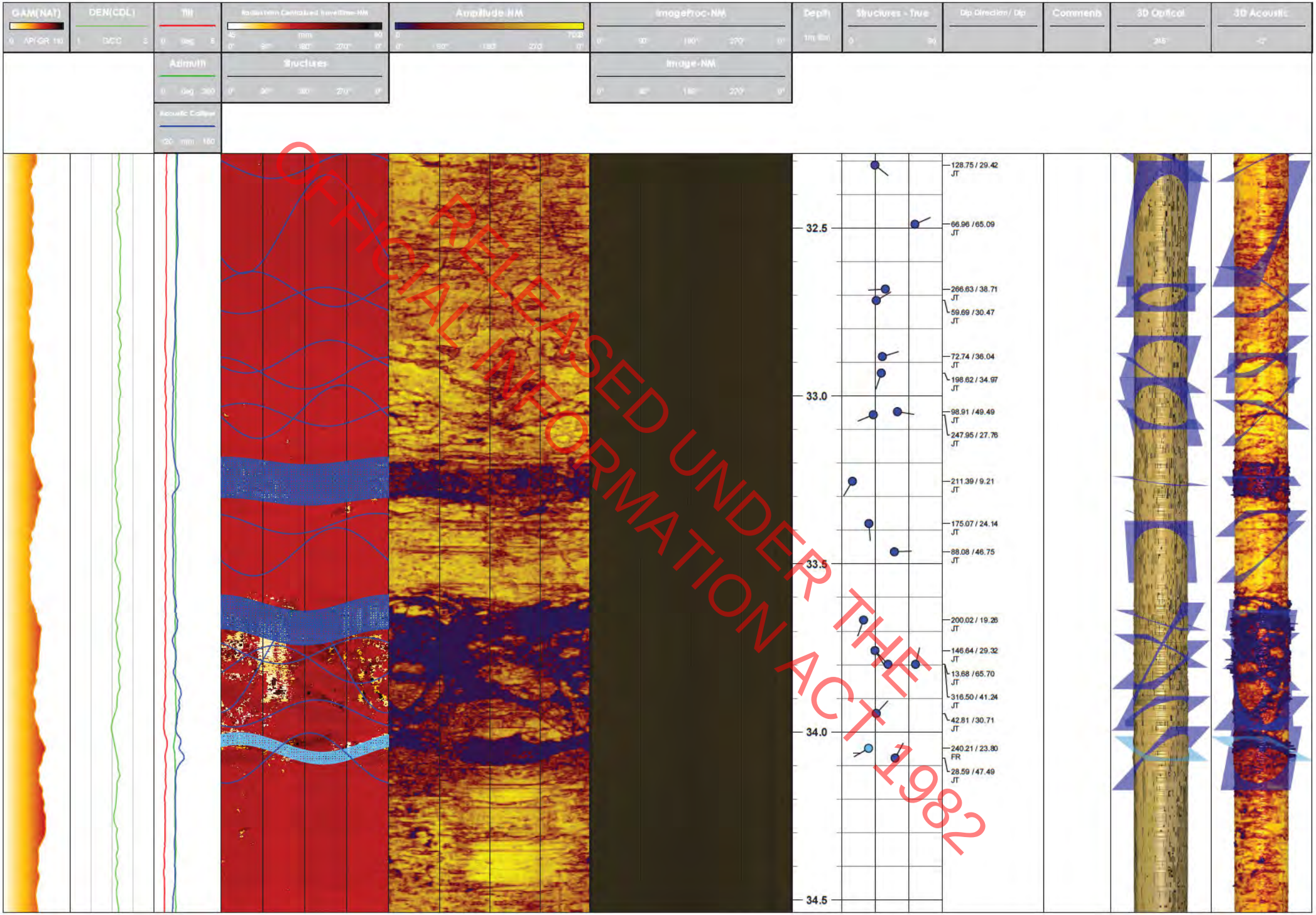

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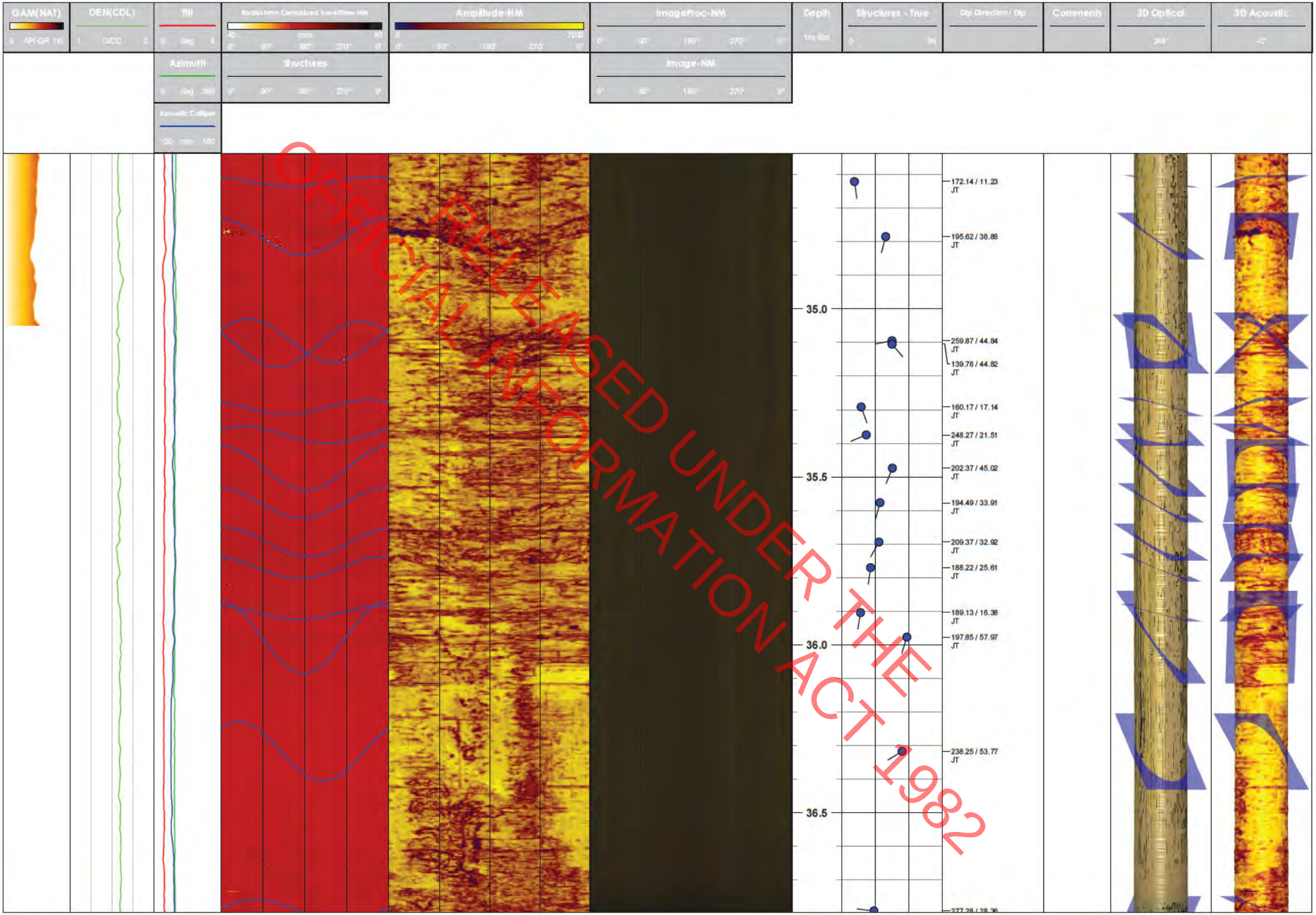

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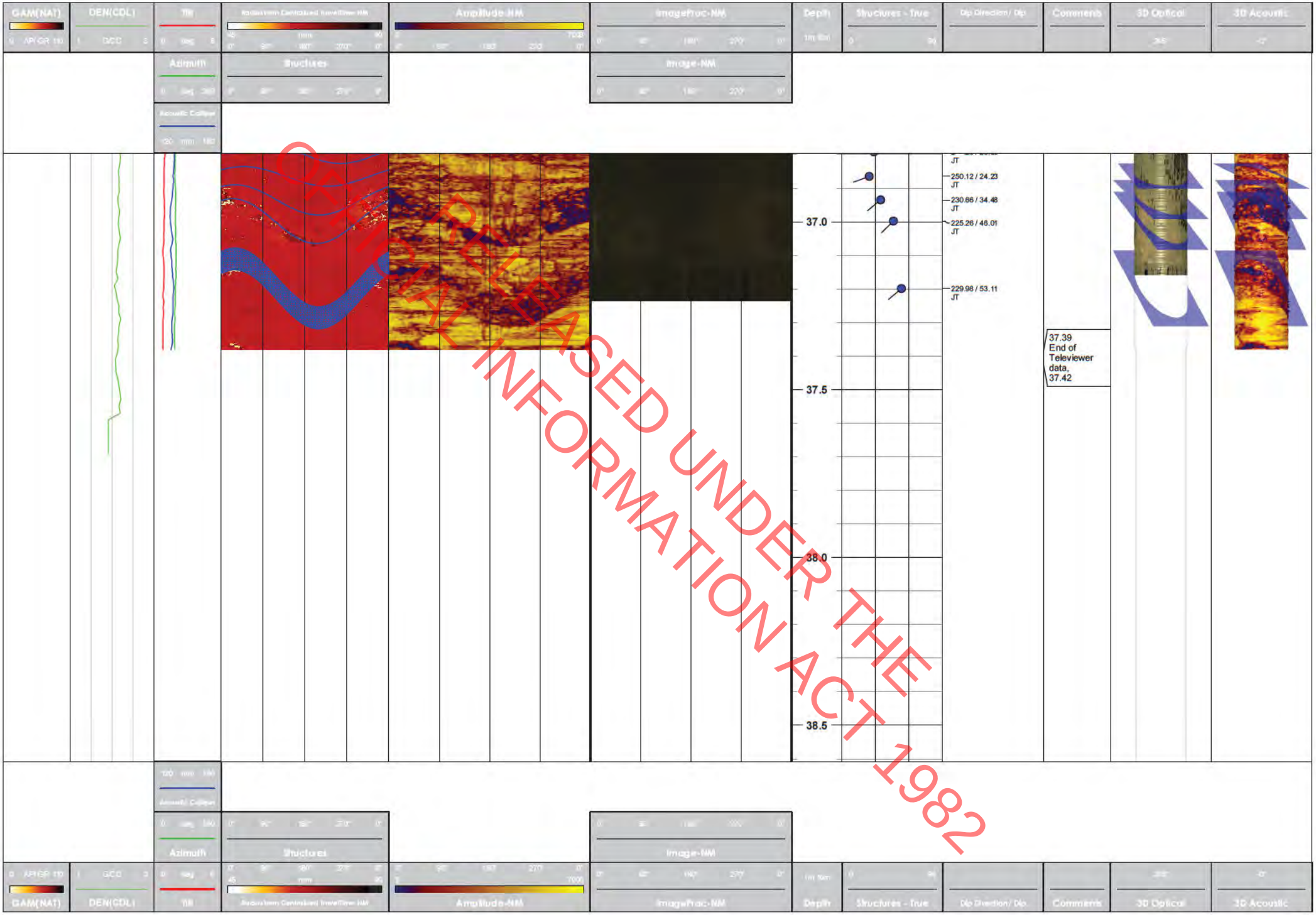

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Appendix B-5 – Installation Records

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Summary of piezometer details

BH_ID	Location	Easting	Northing	R.L (m)	Type	ID	Serial #	Hole depth (mbgl)	Tip depth (mbgl)	Geological Unit	Screen	Zero readings						Datalogged
												Air		Saturated and Submerged		In hole &pre-grout		
												Fr (Hz)	Temp (°)	Fr (Hz)	Temp (°)	Fr (Hz)	Temp (°)	
1106	AUT	400243.582	802972.968	34.216	VW	P1	363401	40.0	37	ECBF	Grout	3028.7	21.4	3024.7	20.7	2594.4	20.6	Y
					VW	P2	36123		10	ECBF-RS	Grout	3122.1	22	3116.6	19.8	3058.5	20.8	Y
1204	Paice Avenue	398352.688	799933.069	42.274	VW	P1	360868	40.0	35.0	ECBF	Grout	3212.2	27.9	3195	23.1	2567.5	22	Y
					VW	P2	356376		9.0	ECBF-RS/TA	Grout	3122.2	29.5	3110.5	25.2	3082.9	23.4	Y
1206	Gribblehirst Park	397804.29	799971.717	34.328	VW	P1	360919	50.0	45.0	ECBF	Grout	3100.8	34.7	3089.5	23.2	2412.3	19.9	Y
					VW	P2	356161		27.0	ECBF-RS/TA	Grout	3017.3	34	2997.2	21.2	2578.6	22.7	Y
					VW	P3	361070		11.0	Basalt	K2 Gravel	3120.3	33.1	3103.7	25.2	2990.7	22.2	Y
1202A	Raleigh Street	398583.292	800426.655	47.215	VW	P1	355580	42.0	40.0	ECBF	Grout	3026.5	23.3	3019.2	19	2576.6	19.1	Y
					VW	P2	360294		30.0	Alluvial	Grout	3073.3	22.7	3066.9	20.5	2867.9	20.3	Y
					VW	P3	361095		20.0	Basalt	K2 Gravel	3122.9	25.6	3117.1	19	2986	21.2	Y
1205A	St Albans Avenue	398381.613	799711.271	39.497	VW	P1	S10958	50.5	43.0	ECBF	Grout	2995.8	24	2993.2	19	2284.1	20.9	Y
1207	Cambourne Road	397813.579	799741.428	35.505	VW	P1	360358	40.5	35.0	ECBF	Grout	3070.9	24	3069.8	21	2417.7	17.7	Y
					VW	P2	355149		7.0	Basalt	K2 Gravel	3091.9	26.4	3089.7	20.8	3023.6	23.5	Y
1208	Lancing Road	397772.955	799483.024	41.569	VW	P1	363258	50.5	50.0	ECBF	Grout	3013.6	24.6	3009.5	22.6	2289.6	20.4	Y
					VW	P2	365140		17.0	Basalt	K2 Gravel	3084.7	24.2	3078.9	22.3	2862.8	21.4	Y
1209A	Patterson St	397940.595	799185.706	44.595	VW	P1	363397	45.0	43.5	ECBF	Grout	3134.2	18.2	3129.2	14.8	2632.9	16.1	N
					VW	P2	366183		18.0	Basalt	Grout	3072.2	19.7	3067.1	14.8	2885.6	17.3	N
1210	Mars Avenue	397640.281	799045.866	42.541	VW	P1	366198	40.5	40.0	ECBF (Eu2)	Grout	3110.7	20.2	3109	19.6	2640.7	18.4	Y
					VW	P2	364119		27.0	Basalt	Grout	3109.7	20.5	3106.4	19.4	2841.6	18.4	Y
1212	Taumata Street	397292.817	798202.987	56.172	VW	P1	363266	40.5	39.0	HW ECBF	Grout	3003	16.9	2999.2	17.2	2510.8	16.7	Y
					VW	P2	365177		9.0	ECBF	Grout	3142	17.2	3137.4	17.3	3075.1	18	Y
1301	Bellevue Road	398955.202	800646.771	69.48	VW	P1	360295	48.4	47.0	ECBF	K2 Gravel	3097	22.3	3091.7	20.6			Y
					VW	P2	361089		42.0	TA [Puketoka Fm]	K2 Gravel	3099.2	22.9	3095	17.6			Y
					VW	P3	361075		35.0	Basalt	K2 Gravel	3111.1	22.7	3108.6	18.1			Y
1302	Ewington Avenue	398812.151	800170.221	59.923	VW	P1	S5620	50.5	40.0	ECBF	K2 Gravel	2983.5	18.5	2975.9	18.3	2603.6	17.4	Y
					VW	P2	365196		9.0	Basalt	K2 Gravel	3126.6	18.1	3123.3	15.1	3127.7	21	Y
1303	Tennyson Street	398411.777	798930.476	48.917	VW	P1	363238	50.0	48.0	ECBF	Grout	3113.2	16.5	3107.4	15.8	2664.7	17	Y
					VW	P2	363229		42.0	TA	Grout	31106	16.9	3104.9	16	2542.4	16.5	Y
					VW	P3	S8191		35.0	Basalt	K2 Gravel	2937.2	17.1	2931.2	15.5	2531	17	Y
1109	St Martins Place	400023.868	802435.741	72.905	VW	P1	S10964	66.0	43.0	ECBF	Grout	2960.7	19.8	2955.6	20.1	2484.2	17	Y
					VW	P2	355862		21.5	ECBF (EU3s/g)	Grout	3066.1	19.7	3058.4	19.8	2923.1	18.1	Y
					VW	P3	355853		17.0	ECBF (Mod. Weath)	Grout	3009.9	20.9	3000.1	20.3	2930	18.9	Y
1404	Quadrant Road	401337.857	795479.996	39.736	VW	P1	363399	50.0	40.0	ECBF	Grout	3114.3	20	3109.7	19.6	2635.2	17.5	Y
1503	Westney Road	401927.218	788198.315	15.547	VW	P1	352104	42.0	41.0	Kawwa Sands	Grout	3149.8	23.3	3143	25.5	2627.3	19	Y
					VW	P2	360322		16.0	TG	Grout	3080.2	24	3073.7	25.8	2967.5	19.6	Y
1107	Wakefield Street	400131.507	802655.579	61.185	VW	P1	363224	60.0	53	ECBF	Grout	2991	16.1	2989.2	15.9	2473	17.3	Y
					VW	P2	365193		12	ECBF (EUs3/EUg3)	Grout	3057	16.1	3053.9	15.4	3056.9	17	Y
1110	Porters Avenue	399117.851	801279.574	66.075	VW	P1	S10961	40.5	40	ECBF	Grout	3010.6	17.4	3005.8	13.5	2486.4	16.9	Y
					VW	P2	365231		9.5	Fill?	Grout	3009.3	13.7	3005.4	13.7	2967.5	17.1	Y
1111	New North Road	398915.187	801193.452	59.891	VW	P1	363396	45.0	40	ECBF	Grout	3139.1	17.7	3133.6	16.5	2658.8	18.6	Y
					VW	P2	365183		7.5	Residual ECBF	Grout	3132.8	19.4	3127.2	16.8	3094.8	19.3	Y
1214	Farrelly Avenue	396794.488	797430.686	52.072	VW	P1	363393	36.0	35	ECBF	Grout	3128.4	25.2	3127.7	23	2769.6	17.4	N
					VW	P2	365182		20	Basalt	Grout	3137.3	24.2	3126.9	22.4	2875	18.4	N
1410	Black Bridge Reserve	402498.108	791692.423	6.89	VW	P1	365113	36.0	33	Kaawa Sands	Grout	3108	20.9	3104.8	20.2	2661.5	19.2	Y
					VW	P2	366178		10.5	Younger Alluvium	Grout	3087.7	20.4	3077.9	20.3	2921.6	19.8	Y
					VW	P3	366166		7	Peat	Grout	3081.8	20.4	3084.4	20.2	2984.5	20	Y
1411	Moyle Park	402689.08	790815.73	5.259	VW	P1	363268	39.0	30	Kaawa Sands	Grout	3084.3	20.2	3084.2	20.4	2673.8	20.4	Y
					VW	P2	365170		15	Tauranga Group	Grout	3084.7	20.1	3084.5	20.3	2875	21.2	Y
1501	Bader Drive	402932.196	790333.881	12.147	VW	P1	366185	34.5	33.5	Kaawa Sands	Grout	3068	22.6	3065.6	22.3	2549.8	17.7	N
					VW	P2	366186		14	Tauranga Group	Grout	2993.5	23.2	2991.4	22.3	2799	19.5	N
2202	Kingsland Station	398287.15	800776.021	47.46	Vw	P1	366196	50.0	48	ECBF (Eu2)	Grout	3044.9	21.6	3041.7	21.6	2424.6	19.6	Y
					VW	P2	366158		22	ECBF RS / Colluvium	Grout	3067.9	23.1	3064.9	21	2860	19.9	Y
					VW	P3	366154		17	Basalt	K2 Gravel	3024.8	22	3021.9	20.8	2902.1	20.2	Y
1406	Onehunga Train Station	401943.499	794962.328	10.833	VW	P1	366231	40.0	38	ECBF	Grout	2870.3	15.5	2865.7	12.4	2322.2	16.7	Y
					VW	P2	366176		15	Basalt	K2 Gravel	3033.8	18	3030	13.8	2907	17.4	Y
1104	Wellesley Street West	399286.46	803454.857	7.75	VW	P1	366103	50.0	35	ECBF	Grout	3082.6	13.5	3081.2	13.6	2532.7	18.4	N
					VW	P2	366181		6	ECBF	Grout	3052.1	13.7	3050.3	13.6	3012.4	19.2	N
2209	Corner of Balmoral and Sandringham	397752.931	799365.254	42.406	VW	P1	363260	48.0	47	ECBF (SW-UW)	K2 Gravel	3046.9	17.9	3043.1	16.9	2454.9	17.3	Y
						P2	366147		37	Tauranga Group	K2 Gravel	3079.6	17.7	3074.3	16.7	2579.2	17.3	Y
						P3	365175		25	Basalt	K2 Gravel	3064.1	17.4	3070	17	2793.7	17.7	Y

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Summary of piezometer details

BH_ID	Location	Easting	Northing	R.L (m)	Type	ID	Serial #	Hole depth (mbgl)	Tip depth (mbgl)	Geological Unit	Screen	Zero readings						Datalogged
												Air		Saturated and Submerged		In hole &pre-grout		
												Fr (Hz)	Temp (°)	Fr (Hz)	Temp (°)	Fr (Hz)	Temp (°)	
2211	Corner of Arabi and Calgary St	397800.018	798586.736	44.123	VW	P1	358426	45.0	42	ECBF(SW-UW)	Grout	3038.6	18	3029.1	17.1	2455.7	16.7	N
						P2	363404		34	Alluvial	Grout	3092.2	16.2	3086.7	16.5	2721.2	16.9	N
						P3	366157		22.5	Basalt	K2 Gravel	3155.2	16.6	3149.5	15	2884.5	16.6	N
2212	Lambeth Road	397678.861	798477.565	43.244	VW	P1	363389	43.5	42	ECBF(SW-UW)	Grout	3083.8	14.2	3087	15.1	2606.5	16.1	N
						P2	366156		23	Alluvial	Grout	3079.2	14.2	3075.7	13.6	2819.4	15.7	N
						P3	366177		16	Basalt	K2 Gravel	3052.9	14.3	3049.4	13.5	2899.4	15.4	N

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Appendix C Calibration Certificates

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Appendix C-1 Handheld Shear Vane Calibration Certificates

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MCC

Calibration Certificate

Certificate No: M719909.25

Certificate Issued To	Aurecon New Zealand Ltd		**Address**	Level 3, Air New Zealand Building 185 Fanshawe Street Wynyard Quarter Auckland 1010	
Purchase Order No	Brent Wilson				
Manufacturer	Geotechnics	**Model**	Geovane	**S/No**	3732
				Unique ID	
Description	Handheld shear vane with matching blade(s)				
Calibration Date	15/12/2022		**Temp During Test**	19.7 to 20.3 °C	
Method	MCC 5.51c.01 – Handheld Soil Shear Vane Testers (2021), Guideline for Hand Held Shear Vane Test (NZGS, 2001) was used as a guide.				

Results

19 mm Ø Vane Blade

Shear Strength = A × Reading	**A (kPa/div)**	**1.704**	**Area Ratio**	23.4%

Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)
0	0	30	51	60	102	90	153	120	204
2	3	32	55	62	106	92	157	122	208
4	7	34	58	64	109	94	160	124	211
6	10	36	61	66	112	96	164	126	215
8	14	38	65	68	116	98	167	128	218
10	17	40	68	70	119	100	170	130	221
12	20	42	72	72	123	102	174	132	225
14	24	44	75	74	126	104	177	134	228
16	27	46	78	76	129	106	181	136	232
18	31	48	82	78	133	108	184	138	235
20	34	50	85	80	136	110	187	140	239
22	37	52	89	82	140	112	191		
24	41	54	92	84	143	114	194		
26	44	56	95	86	147	116	198		
28	48	58	99	88	150	118	201		

The expanded uncertainty of measurement, expressed at the 95% confidence level, is ±7.6 kPa. The coverage factor (k) is 2.

Remarks

When received, this equipment was in new condition.

Measurement results are traceable to the International System of Units (SI), or other recognised references via an unbroken chain of comparisons to the New Zealand National Standards or to the National Standards of other Signatories to the CIPM MRA.

This certificate has been prepared for the benefit of Aurecon New Zealand Ltd, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

This calibration was performed at 1 Hill Street, Onehunga, Auckland, NZ.

Prepared by

s 9(2)(a)

Annalyse Ryan
Metrologist | Team Leader

Checked by

s 9(2)(a)

Agnelo Vaz
Senior Metrologist

Key Technical Person

s 9(2)(a)

Agnelo Vaz
Senior Metrologist

All measurements reported herein have been performed in accordance with the laboratory's scope of accreditation

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MCC

Calibration Certificate

Certificate No: M719909.26

Certificate Issued To	Aurecon New Zealand Ltd		**Address**	Level 3, Air New Zealand Building 185 Fanshawe Street Wynyard Quarter Auckland 1010	
Purchase Order No	Brent Wilson				
Manufacturer	Geotechnics	**Model**	Geovane	**S/No**	3733
				Unique ID	
Description	Handheld shear vane with matching blade(s)				
Calibration Date	15/12/2022		**Temp During Test**	19.9 to 20.6 °C	
Method	MCC 5.51c.01 – Handheld Soil Shear Vane Testers (2021), Guideline for Hand Held Shear Vane Test (NZGS, 2001) was used as a guide.				

Results

19 mm Ø Vane Blade

Shear Strength = A × Reading	**A (kPa/div)**	**1.543**	**Area Ratio**	23.2%

Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)	Reading (div)	Shear Strength (kPa)
0	0	30	46	60	93	90	139	120	185
2	3	32	49	62	96	92	142	122	188
4	6	34	52	64	99	94	145	124	191
6	9	36	56	66	102	96	148	126	194
8	12	38	59	68	105	98	151	128	198
10	15	40	62	70	108	100	154	130	201
12	19	42	65	72	111	102	157	132	204
14	22	44	68	74	114	104	161	134	207
16	25	46	71	76	117	106	164	136	210
18	28	48	74	78	120	108	167	138	213
20	31	50	77	80	123	110	170	140	216
22	34	52	80	82	127	112	173		
24	37	54	83	84	130	114	176		
26	40	56	86	86	133	116	179		
28	43	58	90	88	136	118	182		

The expanded uncertainty of measurement, expressed at the 95% confidence level, is ±7.6 kPa. The coverage factor (k) is 2.

Remarks

When received, this equipment was in new condition.

Measurement results are traceable to the International System of Units (SI), or other recognised references via an unbroken chain of comparisons to the New Zealand National Standards or to the National Standards of other Signatories to the CIPM MRA.

This certificate has been prepared for the benefit of Aurecon New Zealand Ltd, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

This calibration was performed at 1 Hill Street, Onehunga, Auckland, NZ.

Prepared by

s 9(2)(a)

Annalyse Ryan
Metrologist | Team Leader

Checked by

s 9(2)(a)

Agnelo Vaz
Senior Metrologist

Key Technical Person

s 9(2)(a)

Agnelo Vaz
Senior Metrologist

ACCREDITED CALIBRATION LABORATORY

All measurements reported herein have been performed in accordance with the laboratory's scope of accreditation

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Appendix C-2 SPT Hammer Calibration Certificates

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McMillan Drilling Ltd
admin@drilling.co.nz
www.drilling.co.nz
120 High Street
Southbridge 7602
Canterbury, New Zealand
Phone: +64 3 324 2571
Fax: +64 3 324 2431

STANDARD PENETRATION TEST (SPT) HAMMER ENERGY MEASUREMENT CERTIFICATE

Certificate: N118-20220209 Standard: ASTM D4633-10
Date: 9/2/2022

Geotechnical hammer

Type:	Safety Auto	Maker:	Massenza	Mass:	63.5kg	Hammer ID:	N118
Anvil dimensions: 55mm OD, 175mm long				Drop height:	760mm		
Notes:							

Instrumented rod

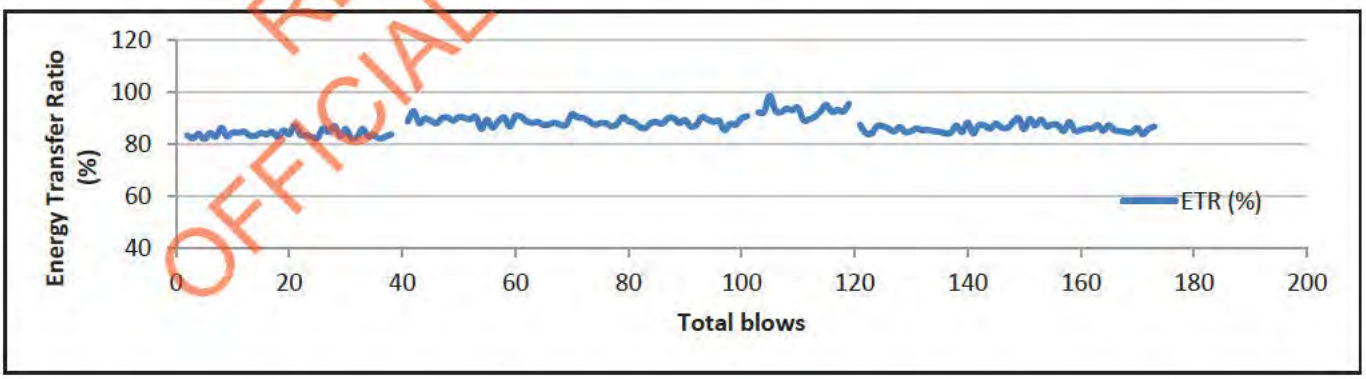
Serial:	591AWJ	Type:	AWJ	Maker:	Pile Dynamics, Inc.	Area:	7.70cm²
Outer diameter:	44.5mm	Inner diameter:	15.9mm	Calibration date:	16/1/2021		
Strain sensor F3:	591AWJ-1	Strain sensor F4:	591AWJ-2	Calibration date:	16/1/2021		
Accelerometer A3:	K3535	Accelerometer A4:	K10904	Calibration date:	27/8/2020		

Processing equipment

Model:	PDA, SPT Analyzer	Maker:	Pile Dynamics, Inc.	Calibration Date:	13/12/2018
Serial:	4077 TA	Sample size:	8k	Sample frequency:	100kHz

Tests

Job No. - Location	Testing site - Sweetcorn Place, Pukekohe				
Test No.	1	2	3	4	5
Borehole	BH001	BH001	BH001	BH001	
Test date	8/2/2022	8/2/2022	8/2/2022	8/2/2022	
Test time	12:09 PM	12:54 PM	2:44 PM	3:30 PM	
Depth below ground level (LP)	12.00m	14.50m	15.00m	16.50m	
Depth below sensors (LE)	13.40m	15.90m	16.35m	17.85m	
No. blows	37	61	17	53	
Average measured blows per minute	22.1	21.3	27.9	23.2	
Average hammer energy efficiency	83.9%	88.7%	92.9%	86.2%	



Total blows analysed	168	Average hammer energy efficiency	87.2%
Standard deviation	3.1		

Tested by: Fraser Bainbridge Signature: s 9(2)(a)

Checked by: Massimo Rinaldo Signature:

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McMillan Drilling Ltd
admin@drilling.co.nz
www.drilling.co.nz
120 High Street
Southbridge 7602
Canterbury, New Zealand
Phone: +64 3 324 2571
Fax: +64 3 324 2431

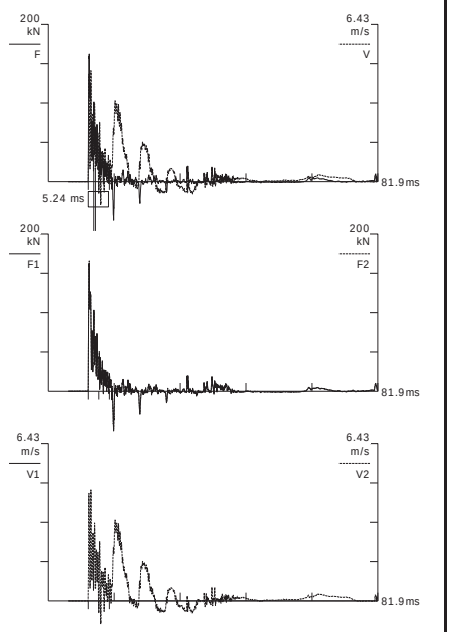
STANDARD PENETRATION TEST (SPT) HAMMER ENERGY MEASUREMENT CERTIFICATE

Certificate: N118-20220209 Standard: ASTM D4633-10

Date: 9/2/2022

Representative reports

Test 1



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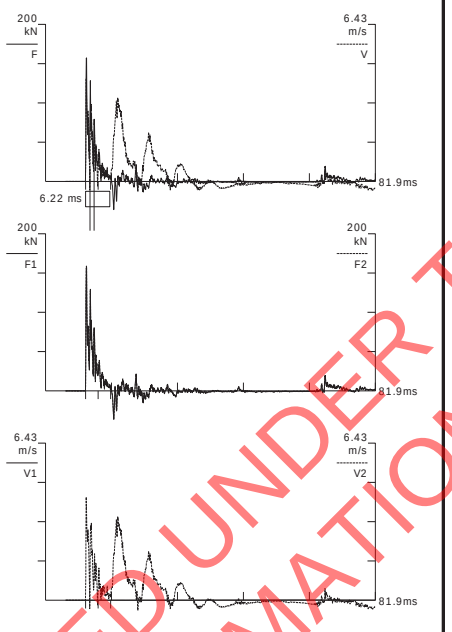

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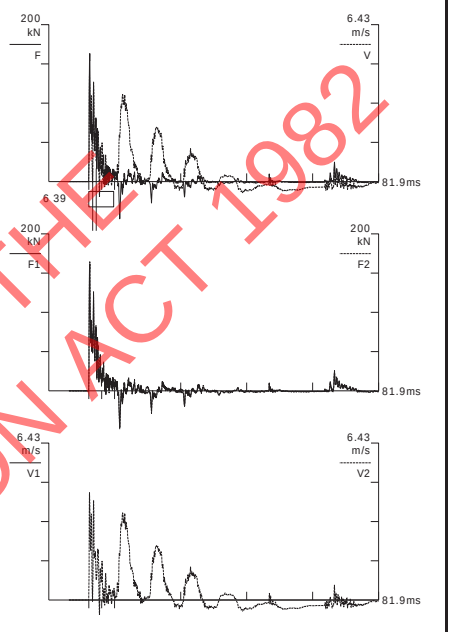

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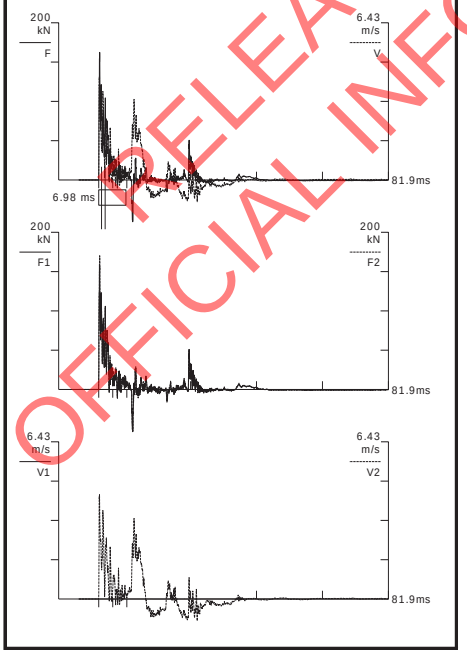

Test 5

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McMILLAN Drilling

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admin@drilling.co.nz
www.drilling.co.nz
120 High Street
Southbridge 7602
Canterbury, New Zealand
Phone: +64 3 324 2571
Fax: +64 3 324 2431

STANDARD PENETRATION TEST (SPT) HAMMER ENERGY MEASUREMENT CERTIFICATE

Certificate: N119-20220712 Standard: ASTM D4633-10

Date: 12/7/2022

Geotechnical hammer

Type:	Safety Auto	Maker:	Comacchio	Mass:	63.5kg	Hammer ID:	N119
Anvil dimensions: 50mm OD, 200mm long				Drop height:	760mm		
Notes:							

Instrumented rod

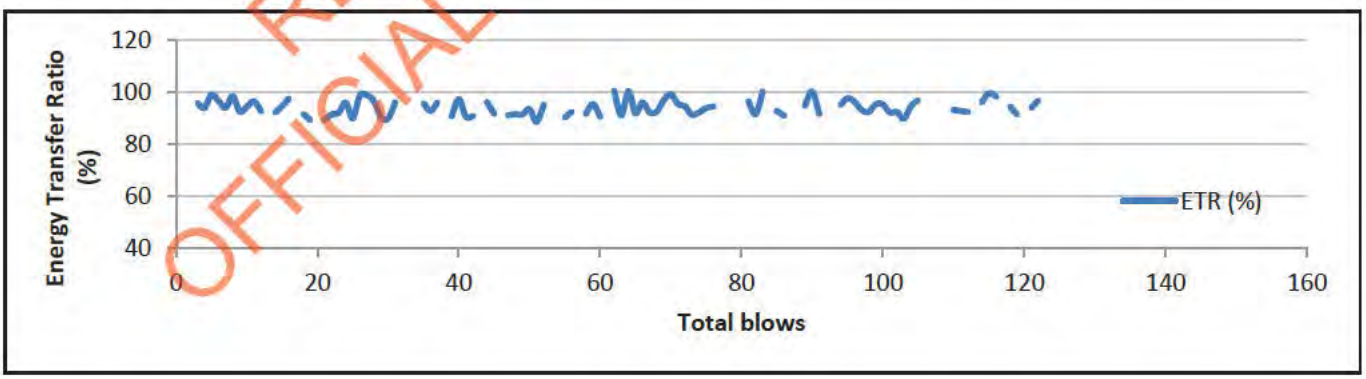
Serial:	346 AWJ - 1	Type:	AWJ	Maker:	Pile Dynamics, Inc.	Area:	7.70cm²
Outer diameter:	44.5mm	Inner diameter:	15.9mm	Calibration date:	16/1/2021		
Strain sensor F3:	591AWJ-1	Strain sensor F4:	591AWJ-2	Calibration date:	16/1/2021		
Accelerometer A3:	K3535	Accelerometer A4:	K10904	Calibration date:	27/8/2020		

Processing equipment

Model:	PDA, SPT Analyzer	Maker:	Pile Dynamics, Inc.	Calibration Date:	13/12/2018
Serial:	4077 TA	Sample size:	8k	Sample frequency:	100kHz

Tests

Job No. - Location	Testing site - Sweetcorn Place, Pukekohe				
Test No.	1	2	3	4	5
Borehole	BH001	BH001	BH001	BH001	
Test date	30/6/2022	30/6/2022	30/6/2022	30/6/2022	
Test time	9:58 AM	10:25 AM	11:07 AM	11:47 AM	
Depth below ground level (LP)	9.30m	9.60m	11.10m	12.80m	
Depth below sensors (LE)	10.70m	11.15m	12.70m	14.25m	
No. blows	15	27	28	27	
Average measured blows per minute	32.8	34.1	34.3	32.6	
Average hammer energy efficiency	94.6%	93.0%	94.3%	94.8%	



Total blows analysed	97	Average hammer energy efficiency	94.1%
Standard deviation	3.0		

Tested by: Jeremy Cain Signature: s 9(2)(a)

Checked by: Greg Cossar Signature:

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McMillan Drilling Ltd
admin@drilling.co.nz
www.drilling.co.nz
120 High Street
Southbridge 7602
Canterbury, New Zealand
Phone: +64 3 324 2571
Fax: +64 3 324 2431

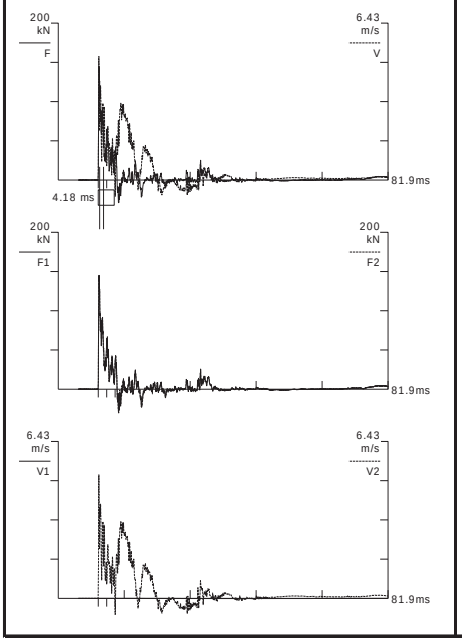
STANDARD PENETRATION TEST (SPT) HAMMER ENERGY MEASUREMENT CERTIFICATE

Certificate: N119-20220712 Standard: ASTM D4633-10

Date: 12/7/2022

Representative reports

Test 1



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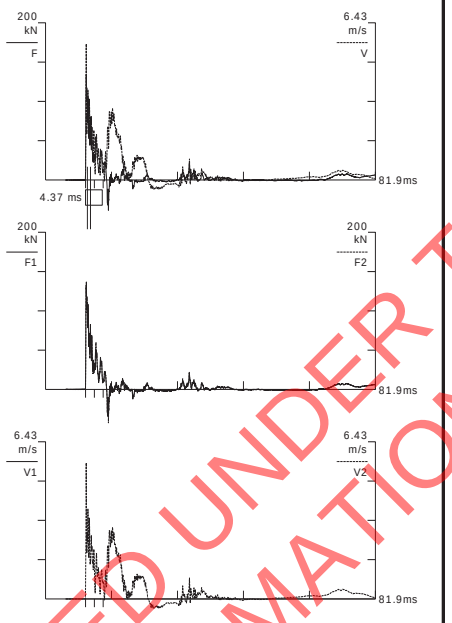

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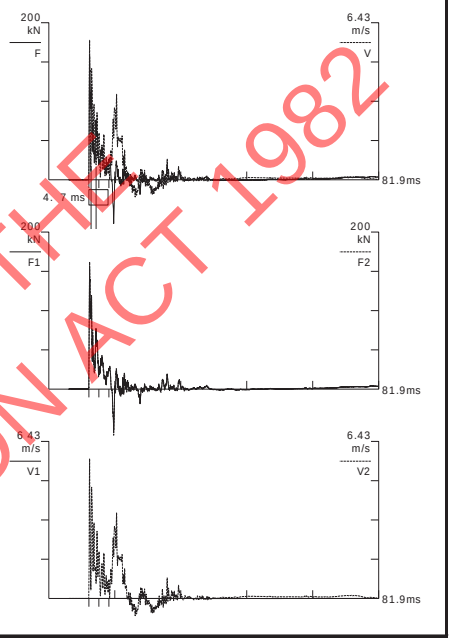

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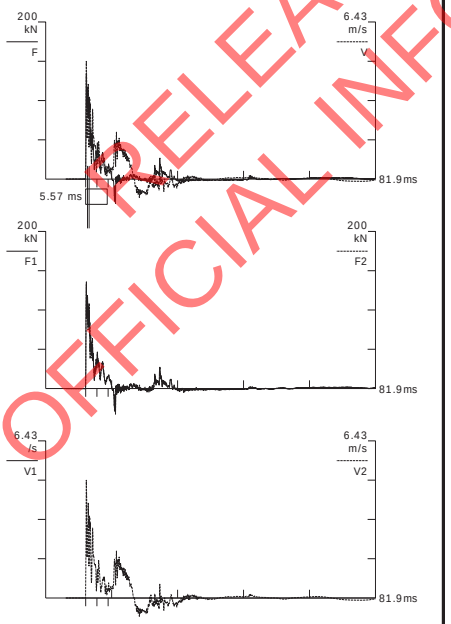

Test 5

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Drill Force NZ Limited
PO Box: 72 335, Papakura 2244
9 Rawson Way, Takanini, Auckland
www.drillforce.co.nz

STANDERD PENETRATION TEST (SPT) HAMMER ENERGY CALIBRATION CERTIFICATE

TEST STANDERD: ASTMD 4633-10
Date: 24/11/2020

TYPE: Manual Trip Hammer
Mass: 63.5 kg
Rig ID: TECHDRILL 150 RIG 99
Hammer ID: DFSH010
Test Location: Mangare East

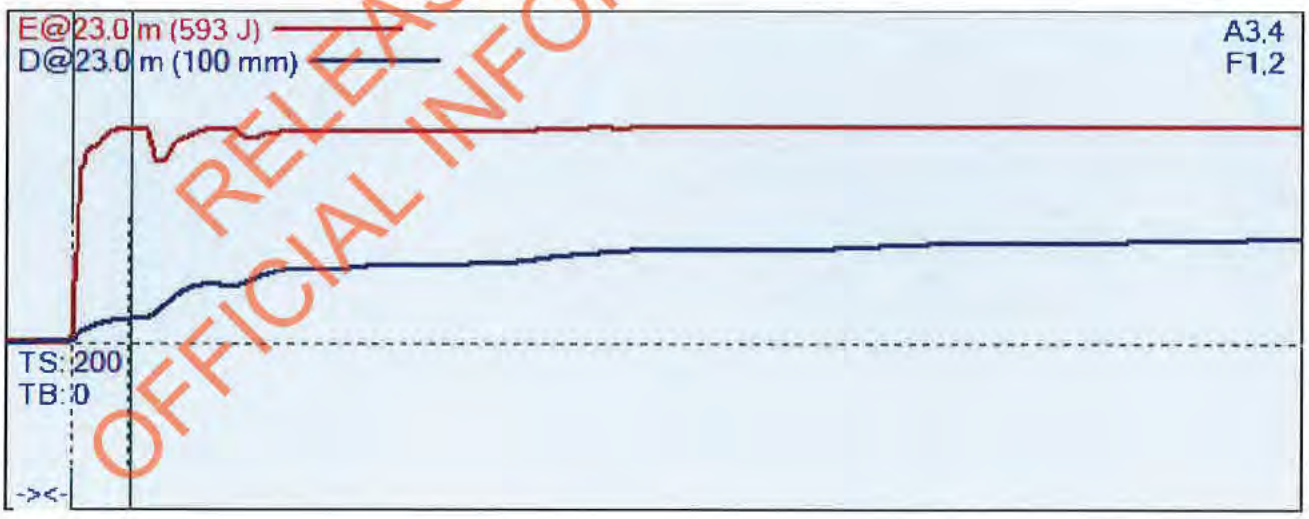
Test No :	TEST 1	TEST 2	TEST 3
Test Depth :	18.00	19.50	21.00
Bore Hole :	BH2008	BH2008	BH2008
Test Date :	24-Nov-20	24-Nov-20	24-Nov-20
Test Time :			
No of Blows :	10	30	13
Standard Deviation	1	1	1

Processing Equipment

Model :	SPT	Maker:	Pile Dynamics Inc USA	Calibration Date:	17/08/2020
Serial No:	4522 TB	Sample Size:	8K	Sample Frequency:	100khz

Test 1	Test 2	Test 3
85.6%	**85.8%**	**87.7%**

Total Blows Analysed : 53	Average Hammer Efficiency	**86.4%**



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Tested by : Don Rajapakse Signature : s 9(2)(a)

Checked by : Ryan Tidswell Signature :

Pile Dynamics, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 24/11/2020

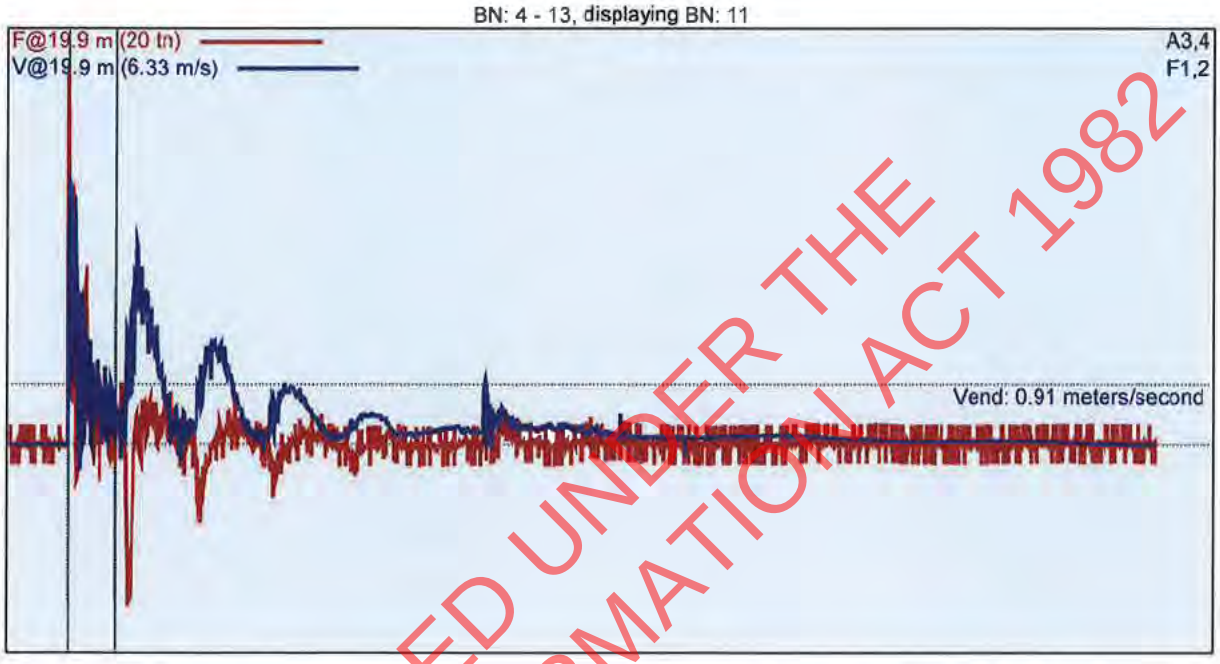
RIG 99
DON
2008

18.00
Test date: 24/11/2020

AR: 7.68 cm^2
LE: 19.9 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 4 - 13, displaying BN: 11



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
4	0	18.00	-18.0	16	82.7	67	67	0.4	3.62	199.6	393
5	0	18.00	-18.0	15	78.9	62	62	0.9	3.64	188.4	374
6	0	18.00	-18.0	18	89.9	55	55	0.2	4.10	224.0	427
7	0	18.00	-18.0	17	87.6	51	51	0.2	3.87	218.6	415
8	0	18.00	-18.0	16	86.0	55	55	0.2	3.80	200.1	408
9	0	18.00	-18.0	17	87.4	43	43	0.2	3.85	211.6	415
10	0	18.00	-18.0	16	85.9	37	37	0.2	3.68	202.2	408
11	0	18.00	-18.0	17	91.8	57	57	0.2	3.80	219.7	435
12	0	18.00	-18.0	16	81.7	44	44	0.2	3.66	205.8	388
13	0	18.00	-18.0	16	84.4	64	64	0.2	3.77	204.4	400
			Average	16	85.6	53	53	0.3	3.78	207.4	406
			Std Dev	1	3.7	9	9	0.2	0.14	10.4	17
			Maximum	18	91.8	67	67	0.9	4.10	224.0	435
			Minimum	15	78.9	37	37	0.2	3.62	188.4	374
					N-value: 10						

Sample Interval Time: 47.46 seconds.

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Summary of SPT Test Results

Project: RIG 99, Test Date: 24/11/2020

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
19.9	-1	0.00	0.00	-18.0	-18.0	0	0	16	85.6	53	53	0.3	3.78	207.4	406
					Overall Average Values:			16	85.6	53	53	0.3	3.78	207.4	406
					Standard Deviation:			1	3.7	9	9	0.2	0.14	10.4	17
					Overall Maximum Value:			18	91.8	67	67	0.9	4.10	224.0	435
					Overall Minimum Value:			15	78.9	37	37	0.2	3.62	188.4	374

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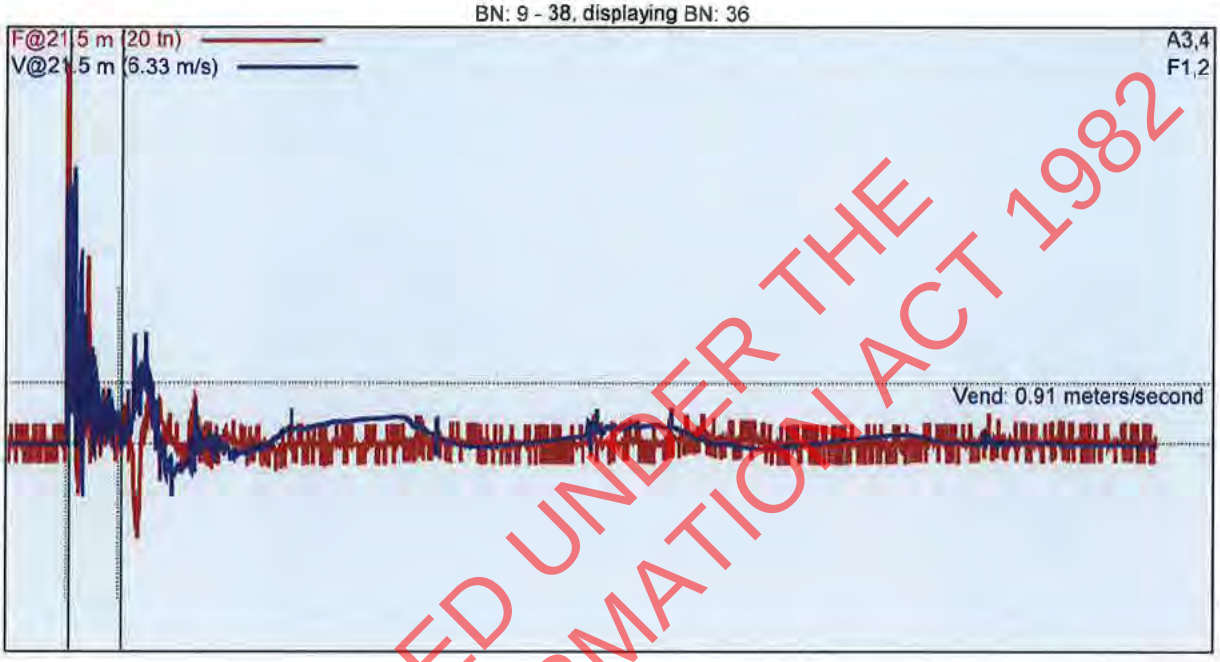
RIG 99
DON
2008

19.50
Test date: 24/11/2020

AR: 7.68 cm^2
LE: 21.5 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 9 - 38, displaying BN: 36



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
9	0	19.50	-19.5	16	82.8	34	34	0.8	3.98	208.3	393
10	0	19.50	-19.5	17	90.0	28	28	0.2	4.05	221.4	427
11	0	19.50	-19.5	18	87.7	29	29	0.2	4.08	227.2	416
12	0	19.50	-19.5	16	83.1	33	33	0.2	3.87	200.4	394
13	0	19.50	-19.5	17	88.5	41	41	0.2	3.96	217.9	420
14	0	19.50	-19.5	15	95.2	67	67	0.3	3.98	191.4	452
15	0	19.50	-19.5	17	84.9	27	27	0.2	4.03	212.6	403
16	0	19.50	-19.5	17	86.7	37	37	0.2	3.82	223.3	411
17	0	19.50	-19.5	17	87.6	37	37	0.2	3.72	217.5	416
18	0	19.50	-19.5	17	89.2	39	39	0.2	3.76	220.8	423
19	0	19.50	-19.5	18	89.4	39	39	0.2	3.97	226.7	424
20	0	19.50	-19.5	15	80.7	36	36	0.3	3.64	191.4	383
21	0	19.50	-19.5	16	82.8	28	28	0.2	3.69	207.0	393
22	0	19.50	-19.5	17	93.6	43	43	0.2	3.85	221.3	444
23	0	19.50	-19.5	17	87.6	35	35	0.2	3.82	222.3	416
24	0	19.50	-19.5	18	91.0	37	37	0.2	3.91	229.8	432
25	0	19.50	-19.5	17	87.3	36	36	0.2	3.87	223.4	414
26	0	19.50	-19.5	16	82.2	33	33	0.2	3.78	201.1	390
27	0	19.50	-19.5	16	84.2	32	32	0.2	3.89	208.4	400
28	0	19.50	-19.5	16	80.1	26	25	0.2	3.85	205.0	380
29	0	19.50	-19.5	17	88.7	29	29	0.2	4.09	219.8	421
30	0	19.50	-19.5	17	83.7	25	25	0.2	3.88	214.3	397
31	0	19.50	-19.5	17	85.1	25	24	0.2	3.92	223.2	404
32	0	19.50	-19.5	18	88.2	30	30	0.2	3.96	226.5	418
33	0	19.50	-19.5	17	85.3	25	25	0.2	3.96	214.7	405
34	0	19.50	-19.5	15	80.9	20	19	0.2	3.72	190.8	384
35	0	19.50	-19.5	17	83.8	27	27	0.2	3.82	211.1	398

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36	0	19.50	-19.5	17	85.9	24	23	0.2	3.91	222.1	408
37	0	19.50	-19.5	17	82.8	19	19	0.2	3.74	214.8	393
38	0	19.50	-19.5	15	75.7	16	15	0.2	3.66	196.7	359
			Average	17	85.8	32	32	0.2	3.87	213.7	407
			Std Dev	1	4.1	9	9	0.1	0.12	11.2	19
			Maximum	18	95.2	67	67	0.8	4.09	229.8	452
			Minimum	15	75.7	16	15	0.2	3.64	190.8	359

N-value: 30

Sample Interval Time: 173.25 seconds.

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Summary of SPT Test Results

Project: RIG 99, Test Date: 24/11/2020

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
21.5	-1	0.00	0.00	-19.5	-19.5	0	0	17	85.8	32	32	0.2	3.87	213.7	407
					Overall Average Values:			17	85.8	32	32	0.2	3.87	213.7	407
					Standard Deviation:			1	4.1	9	9	0.1	0.12	11.2	19
					Overall Maximum Value:			18	95.2	67	67	0.8	4.09	229.8	452
					Overall Minimum Value:			15	75.7	16	15	0.2	3.64	190.8	359

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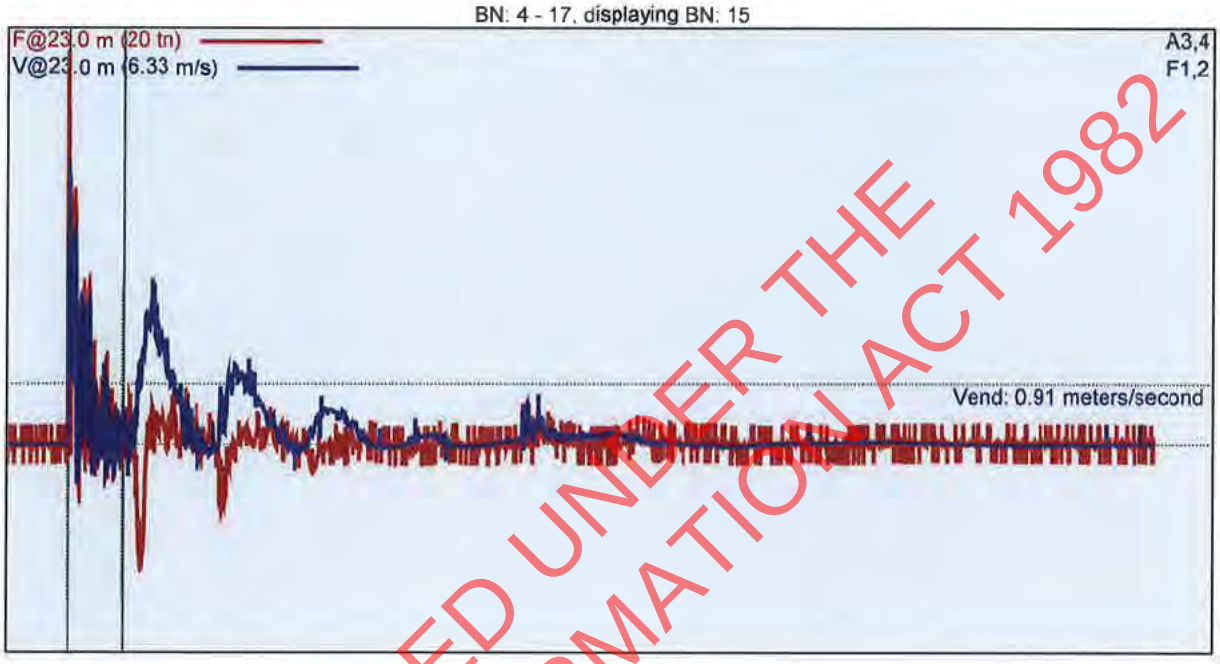
RIG 99
DON
2008

21.00
Test date: 24/11/2020

AR: 7.68 cm^2
LE: 23.0 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 4 - 17, displaying BN: 15



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
4	0	21.00	-21.0	18	88.4	53	53	0.2	3.72	231.8	419
5	0	21.00	-21.0	17	90.7	71	71	0.3	3.62	214.4	430
6	0	21.00	-21.0	17	86.2	43	43	0.2	3.86	215.8	409
7	0	21.00	-21.0	18	89.7	48	48	0.2	3.84	229.4	425
8	0	21.00	-21.0	18	88.3	39	39	0.2	3.71	229.2	419
9	0	21.00	-21.0	16	85.5	45	45	0.3	3.65	210.2	406
10	0	21.00	-21.0	16	88.0	49	49	0.3	3.68	203.9	418
11	0	21.00	-21.0	16	81.6	25	25	0.2	3.72	208.6	387
13	0	21.00	-21.0	17	94.8	76	76	0.3	3.69	214.5	450
14	0	21.00	-21.0	17	90.7	63	63	0.2	3.69	214.6	430
15	0	21.00	-21.0	18	89.0	33	33	0.2	4.00	230.0	422
16	0	21.00	-21.0	16	86.6	51	51	0.2	3.60	199.2	411
17	0	21.00	-21.0	16	80.7	31	31	0.3	3.63	207.0	383
			Average	17	87.7	48	48	0.2	3.72	216.0	416
			Std Dev	1	3.6	14	14	0.1	0.11	10.4	17
			Maximum	18	94.8	76	76	0.3	4.00	231.8	450
			Minimum	16	80.7	25	25	0.2	3.60	199.2	383
					N-value: 13						

Sample Interval Time: 78.34 seconds.

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Summary of SPT Test Results

Project: RIG 99, Test Date: 24/11/2020

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
23.0	-1	0.00	0.00	-21.0	-21.0	0	0	17	87.7	48	48	0.2	3.72	216.0	416
							Overall Average Values:	17	87.7	48	48	0.2	3.72	216.0	416
							Standard Deviation:	1	3.6	14	14	0.1	0.11	10.4	17
							Overall Maximum Value:	18	94.8	76	76	0.3	4.00	231.8	450
							Overall Minimum Value:	16	80.7	25	25	0.2	3.60	199.2	383

Drill Force NZ Limited
PO Box: 72 335, Papakura 2244
9 Rawson Way, Takanini, Auckland
www.drillforce.co.nz

STANDERD PENETRATION TEST (SPT) HAMMER ENERGY CALIBRATION CERTIFICATE

TEST STANDERD: **ASTMD 4633-10**
Date: 26/11/2020

TYPE: Auto Trip Hammer
Mass: 63.5 kg
Rig ID: TECHDRILL 150 RIG 99
Hammer ID: DFSH099
Test Location: Mangare East

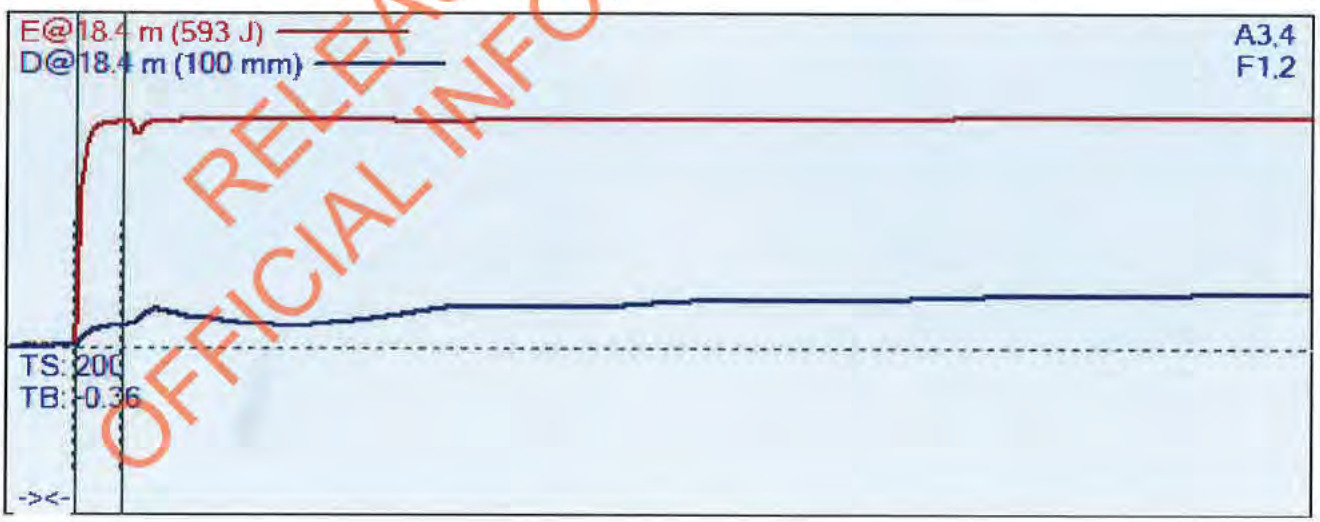
Test No :	TEST 1	TEST 2	TEST 3
Test Depth :	12.00	13.50	16.50
Bore Hole :	BH2005	BH2005	BH2005
Test Date :	26-Nov-20	26-Nov-20	26-Nov-20
Test Time :			
No of Blows :	14	12	11
Standard Deviation	1	1	1

Processing Equipment

Model :	SPT	Maker:	Pile Dynamics Inc USA	Calibration Date:	17/08/2020
Serial No:	4522 TB	Sample Size:	8K	Sample Frequency:	100khz

Test 1	Test 2	Test 3
81.5%	77.2%	84.8%

Total Blows Analysed : 37	Average Hammer Efficiency	81.2%



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Tested by : Don Rajapakse Signature : s 9(2)(a)

Checked by : Ryan Tidswell Signature : s 9(2)(a)

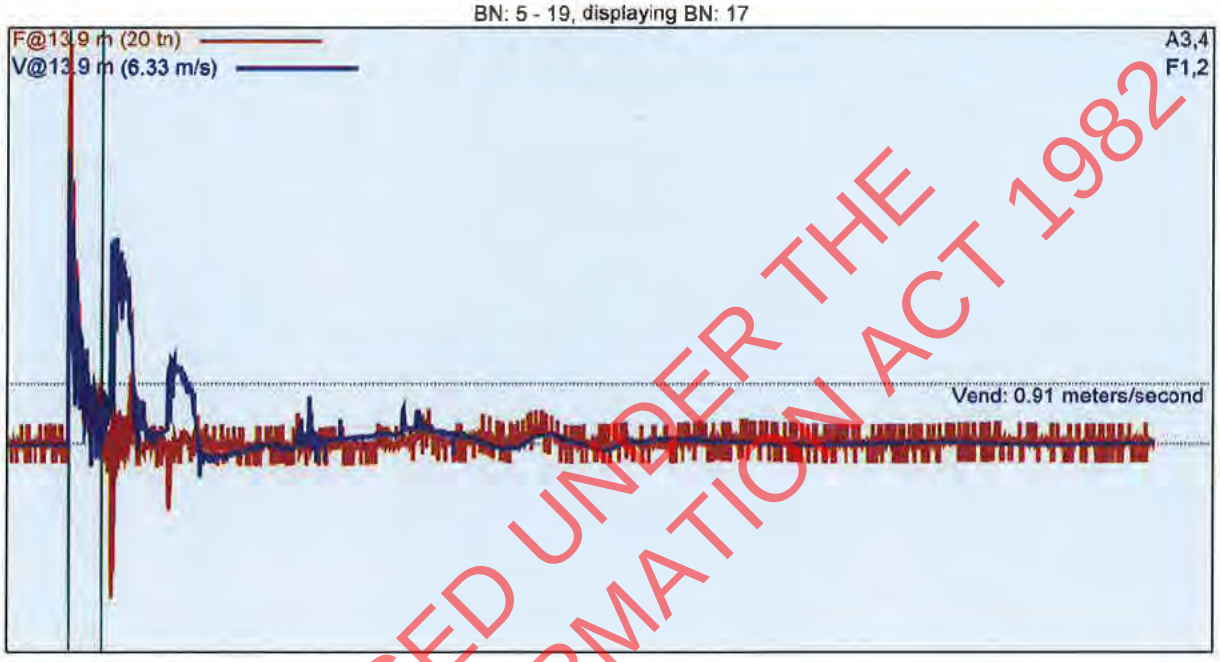
RIG 99 AUTO S.P.T
DON
2005

12.00
Test date: 26/11/2020

AR: 7.68 cm^2
LE: 13.9 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 5 - 19, displaying BN: 17



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
5	0	12.00	-12.0	18	82.8	28	28	1.1	4.39	234.0	393
6	0	12.00	-12.0	18	82.1	25	25	1.1	4.43	230.5	390
7	0	12.00	-12.0	17	82.0	26	26	1.1	4.35	219.8	389
8	0	12.00	-12.0	17	81.2	25	25	1.1	4.27	221.7	385
9	0	12.00	-12.0	17	81.3	23	23	1.1	4.25	221.2	386
10	0	12.00	-12.0	17	78.9	28	28	1.1	3.73	218.7	374
12	0	12.00	-12.0	17	76.5	25	25	1.1	3.66	220.8	363
13	0	12.00	-12.0	19	84.0	25	25	1.1	4.12	243.0	399
14	0	12.00	-12.0	18	79.9	23	23	1.1	3.93	225.5	379
15	0	12.00	-12.0	18	82.9	24	24	1.1	4.31	224.2	393
16	0	12.00	-12.0	18	84.8	24	24	1.1	4.34	229.2	402
17	0	12.00	-12.0	18	83.6	26	26	1.1	4.18	232.8	397
18	0	12.00	-12.0	17	81.1	27	27	1.1	4.30	219.1	385
19	0	12.00	-12.0	17	79.6	28	28	1.1	3.85	212.3	378
			Average	18	81.5	26	26	1.1	4.15	225.2	387
			Std Dev	1	2.1	2	2	0.0	0.24	7.6	10
			Maximum	19	84.8	28	28	1.1	4.43	243.0	402
			Minimum	17	76.5	23	23	1.1	3.66	212.3	363
					N-value: 14						

Sample Interval Time: 82.02 seconds.

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Summary of SPT Test Results

Project: RIG 99 AUTO S.P.T, Test Date: 26/11/2020

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
13.9	-1	0.00	0.00	-12.0	-12.0	0	0	18	81.5	26	26	1.1	4.15	225.2	387
							Overall Average Values:	18	81.5	26	26	1.1	4.15	225.2	387
							Standard Deviation:	1	2.1	2	2	0.0	0.24	7.6	10
							Overall Maximum Value:	19	84.8	28	28	1.1	4.43	243.0	402
							Overall Minimum Value:	17	76.5	23	23	1.1	3.66	212.3	363

Pile Dynamics, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 26/11/2020

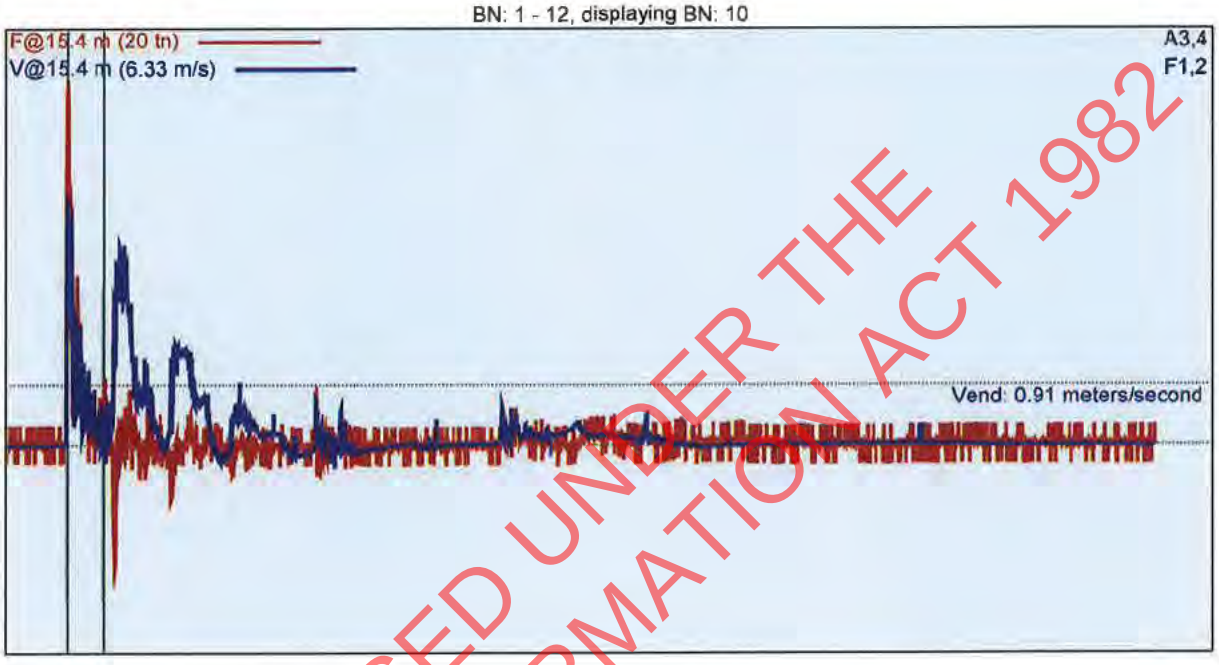
RIG 99 AUTO S.P.T
DON
2005

13.50
Test date: 26/11/2020

AR: 7.68 cm^2
LE: 15.4 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 1 - 12, displaying BN: 10



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
1	0	13.50	-13.5	19	83.0	30	30	0.7	4.00	244.6	394
2	0	13.50	-13.5	18	77.4	27	27	0.7	3.42	235.1	367
3	0	13.50	-13.5	15	73.1	31	31	1.2	3.15	192.5	347
4	0	13.50	-13.5	19	80.3	31	31	0.7	3.71	245.7	381
5	0	13.50	-13.5	18	79.0	34	34	0.8	3.79	230.5	375
6	0	13.50	-13.5	19	80.4	36	36	0.7	3.94	237.1	381
7	0	13.50	-13.5	14	74.2	34	34	1.2	3.25	184.0	352
8	0	13.50	-13.5	15	72.0	30	30	0.7	3.36	193.7	342
9	0	13.50	-13.5	15	73.8	29	29	1.2	3.20	191.2	350
10	0	13.50	-13.5	17	76.0	30	30	1.2	3.49	211.2	361
11	0	13.50	-13.5	19	81.7	26	26	0.6	3.91	242.8	387
12	0	13.50	-13.5	16	75.3	21	21	1.2	3.06	199.8	358
			Average	17	77.2	30	30	0.9	3.52	217.4	366
			Std Dev	2	3.5	4	4	0.2	0.32	23.1	16
			Maximum	19	83.0	36	36	1.2	4.00	245.7	394
			Minimum	14	72.0	21	21	0.6	3.06	184.0	342

N-value: 12

Sample Interval Time: 26.82 seconds.

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Summary of SPT Test Results

Project: RIG 99 AUTO S.P.T, Test Date: 26/11/2020

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
15.4	-1	0.00	0.00	-13.5	-13.5	0	0	17	77.2	30	30	0.9	3.52	217.4	366
							Overall Average Values:	17	77.2	30	30	0.9	3.52	217.4	366
							Standard Deviation:	2	3.5	4	4	0.2	0.32	23.1	16
							Overall Maximum Value:	19	83.0	36	36	1.2	4.00	245.7	394
							Overall Minimum Value:	14	72.0	21	21	0.6	3.06	184.0	342

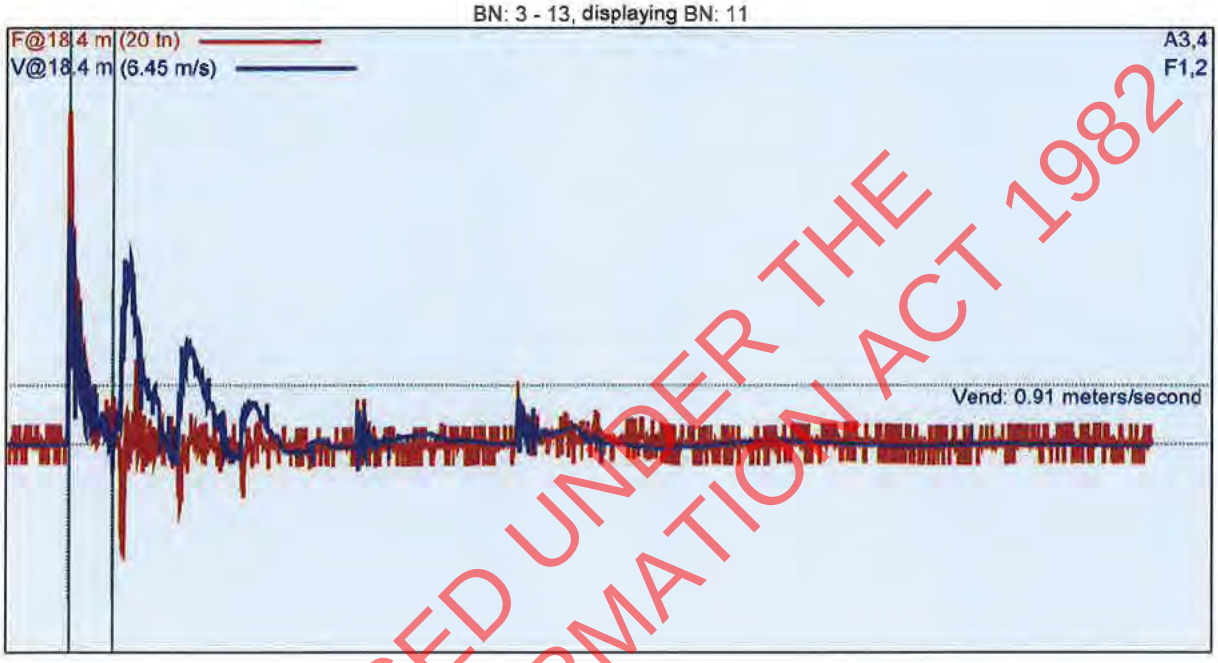
RIG 99 AUTO S.P.T
DON
2005

16.50
Test date: 26/11/2020

AR: 7.68 cm^2
LE: 18.4 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 3 - 13, displaying BN: 11



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
3	0	16.50	-16.5	19	84.8	46	46	0.6	4.00	247.8	402
4	0	16.50	-16.5	19	84.9	37	37	1.1	3.87	240.3	403
5	0	16.50	-16.5	19	86.8	35	35	0.6	3.96	241.7	412
6	0	16.50	-16.5	18	84.4	37	37	0.6	3.91	235.1	400
7	0	16.50	-16.5	18	85.2	33	33	1.1	3.78	234.1	404
8	0	16.50	-16.5	19	85.7	33	32	1.1	3.92	237.4	407
9	0	16.50	-16.5	19	83.6	41	41	0.6	3.93	237.9	397
10	0	16.50	-16.5	19	84.7	36	36	0.6	3.97	244.2	402
11	0	16.50	-16.5	15	81.0	30	30	0.7	3.30	197.0	385
12	0	16.50	-16.5	19	86.0	14	13	0.6	3.87	238.0	408
13	0	16.50	-16.5	19	85.4	16	16	1.1	3.95	241.3	405
			Average	18	84.8	33	32	0.8	3.86	235.9	402
			Std Dev	1	1.4	9	9	0.2	0.19	12.9	7
			Maximum	19	86.8	46	46	1.1	4.00	247.8	412
			Minimum	15	81.0	14	13	0.6	3.30	197.0	385
					N-value: 11						

Sample Interval Time: 36.89 seconds.

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Summary of SPT Test Results

Project: RIG 99 AUTO S.P.T, Test Date: 26/11/2020

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
18.4	-1	0.00	0.00	-16.5	-16.5	0	0	18	84.8	33	32	0.8	3.86	235.9	402
						Overall Average Values:		18	84.8	33	32	0.8	3.86	235.9	402
						Standard Deviation:		1	1.4	9	9	0.2	0.19	12.9	7
						Overall Maximum Value:		19	86.8	46	46	1.1	4.00	247.8	412
						Overall Minimum Value:		15	81.0	14	13	0.6	3.30	197.0	385

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Drill Force NZ Limited
PO Box: 72 335, Papakura 2244
9 Rawson Way, Takanini, Auckland
www.drillforce.co.nz

STANDERD PENETRATION TEST (SPT) HAMMER ENERGY CALIBRATION CERTIFICATE

TEST STANDERD: ASTMD 4633-10
Date: 11/03/2021

TYPE: Manual Trip Hammer
Mass: 63.5 kg
Rig ID: Rig 81 TechDrill 200
Hammer ID: DFSH006
Test Location: Drury

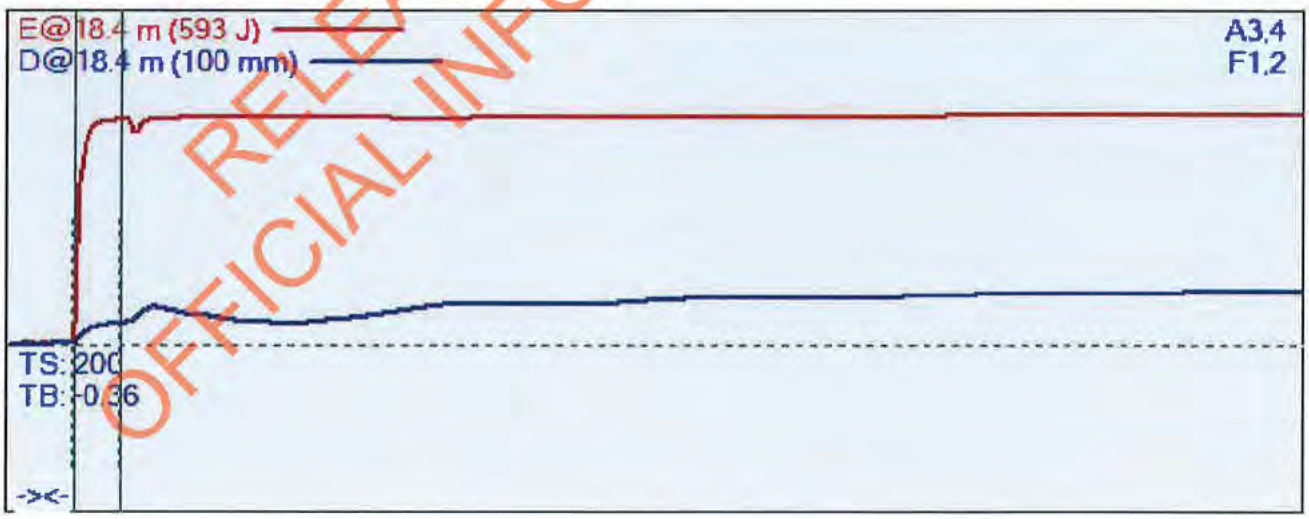
Test No :	TEST 1	TEST 2	TEST 3
Test Depth :	9.00	12.00	13.60
Bore Hole :	BH 03	BH 03	BH 03
Test Date :	11-Mar-21	11-Mar-21	11-Mar-21
Test Time :			
No of Blows :	14	11	9
Standard Deviation	2.7	1.4	1.0

Processing Equipment

Model :	SPT	Maker:	Pile Dynamics Inc USA	Calibration Date:	17/08/2020
Serial No:	4522 TB	Sample Size:	8K	Sample Frequency:	100khz

Test 1	Test 2	Test 3
81.7%	**83.1%**	**81.2%**

Total Blows Analysed : 34	Average Hammer Efficiency	**82.0%**



Tested by : Don Rajapakse Signature : s 9(2)(a)

Checked by : Ryan Tidswell Signature : s 9(2)(a)

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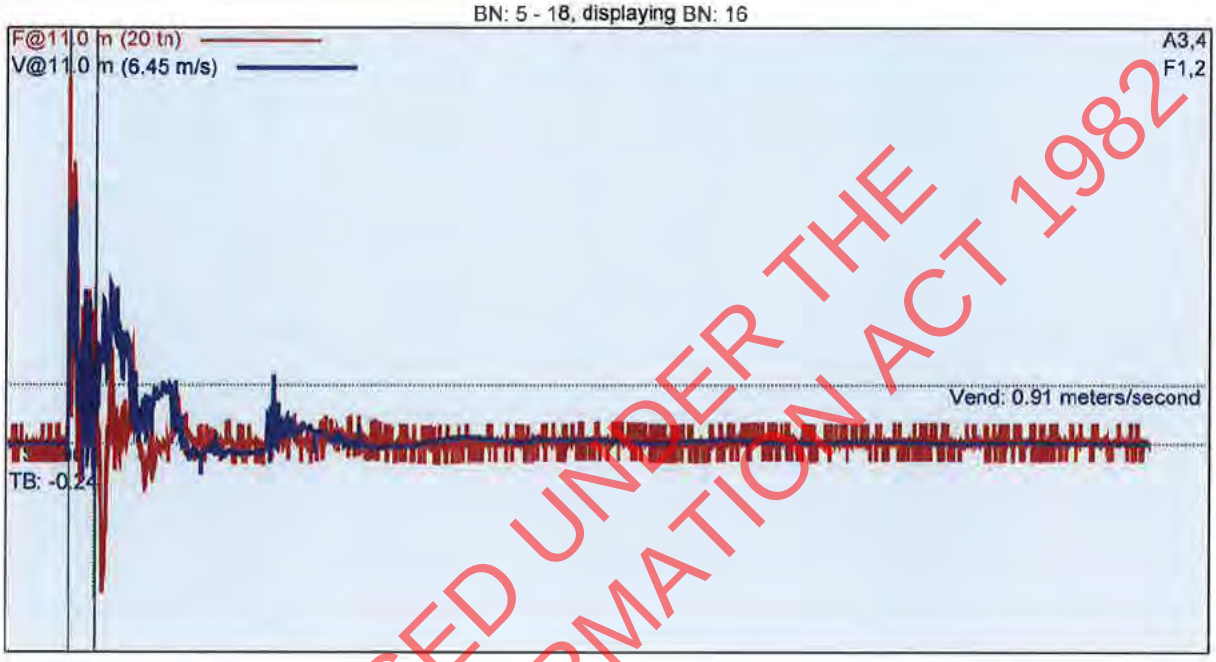
RIG81-
DON
BH-03

9.00m
Interval start: 11/03/2021

AR: 7.68 cm^2
LE: 11.0 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 5 - 18, displaying BN: 16



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
5	0	9.00	-9.0	18	83.2	46	46	0.4	3.89	225.3	395
6	0	9.00	-9.0	17	78.1	33	33	0.4	3.60	218.3	371
7	0	9.00	-9.0	17	79.0	39	39	0.4	3.93	212.8	375
8	0	9.00	-9.0	17	79.2	36	36	0.4	3.79	221.0	376
9	0	9.00	-9.0	14	84.5	40	40	0.4	3.27	182.0	401
10	0	9.00	-9.0	17	78.4	29	29	0.4	3.74	216.0	372
11	0	9.00	-9.0	17	78.8	31	31	0.4	3.70	220.4	374
12	0	9.00	-9.0	18	82.3	34	34	0.4	3.86	226.0	390
13	0	9.00	-9.0	17	83.4	30	30	0.5	3.77	215.7	396
14	0	9.00	-9.0	17	84.6	33	33	0.5	3.84	216.3	401
15	0	9.00	-9.0	16	82.9	34	34	1.1	3.32	204.0	394
16	0	9.00	-9.0	17	79.8	24	24	0.4	3.72	217.5	379
17	0	9.00	-9.0	17	86.5	37	37	0.5	3.95	218.9	411
18	0	9.00	-9.0	17	83.5	29	29	1.2	3.68	211.4	396
			Average	17	81.7	34	34	0.5	3.72	214.7	388
			Std Dev	1	2.7	5	5	0.2	0.20	10.5	13
			Maximum	18	86.5	46	46	1.2	3.95	226.0	411
			Minimum	14	78.1	24	24	0.4	3.27	182.0	371
					N-value: 14						

Sample Interval Time: 47.85 seconds.

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Summary of SPT Test Results

Project: RIG81-, Test Date: 11/03/2021

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
11.0	-1	0.00	0.00	-9.0	-9.0	0	0	17	81.7	34	34	0.5	3.72	214.7	388
							Overall Average Values:	17	81.7	34	34	0.5	3.72	214.7	388
							Standard Deviation:	1	2.7	5	5	0.2	0.20	10.5	13
							Overall Maximum Value:	18	86.5	46	46	1.2	3.95	226.0	411
							Overall Minimum Value:	14	78.1	24	24	0.4	3.27	182.0	371

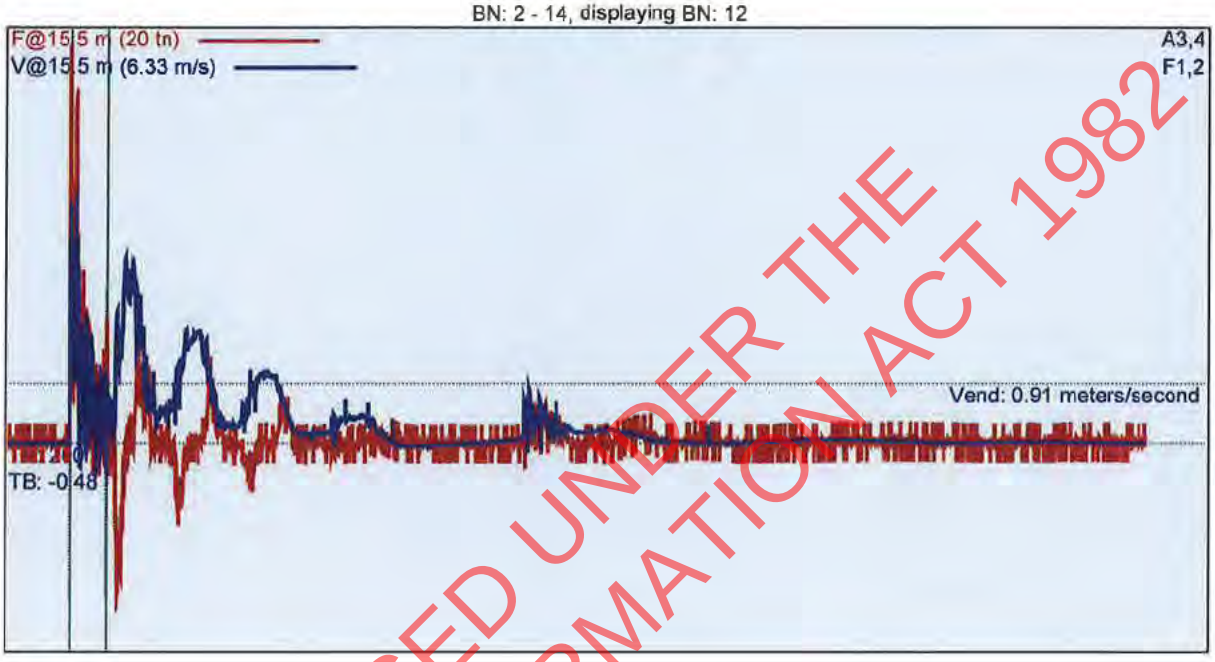
RIG81-
DON
BH-03

13.60
Interval start: 11/03/2021

AR: 7.68 cm^2
LE: 15.5 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 2 - 14, displaying BN: 12



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
2	0	13.60	-13.6	18	82.1	35	35	0.5	4.29	225.1	390
3	0	13.60	-13.6	18	82.0	33	33	0.7	4.08	226.5	389
4	0	13.60	-13.6	19	81.7	35	35	1.1	4.27	237.6	388
5	0	13.60	-13.6	16	80.2	34	34	0.7	4.22	209.3	381
8	0	13.60	-13.6	18	80.0	35	35	0.6	3.84	233.6	380
10	0	13.60	-13.6	18	79.7	41	41	0.5	3.76	231.6	378
12	0	13.60	-13.6	18	82.7	47	47	0.6	3.67	233.2	392
13	0	13.60	-13.6	17	81.0	49	49	0.6	3.57	222.6	384
14	0	13.60	-13.6	19	81.9	51	51	0.5	3.69	240.3	388
			Average	18	81.2	40	40	0.7	3.93	228.9	386
			Std Dev	1	1.0	7	7	0.2	0.27	8.8	5
			Maximum	19	82.7	51	51	1.1	4.29	240.3	392
			Minimum	16	79.7	33	33	0.5	3.57	209.3	378

N-value: 9

Sample Interval Time: 63.98 seconds.

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Summary of SPT Test Results

Project: RIG81-, Test Date: 11/03/2021

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
15.5	-1	0.00	0.00	-13.6	-13.6	0	0	18	81.2	40	40	0.7	3.93	228.9	386
					Overall Average Values:			18	81.2	40	40	0.7	3.93	228.9	386
					Standard Deviation:			1	1.0	7	7	0.2	0.27	8.8	5
					Overall Maximum Value:			19	82.7	51	51	1.1	4.29	240.3	392
					Overall Minimum Value:			16	79.7	33	33	0.5	3.57	209.3	378

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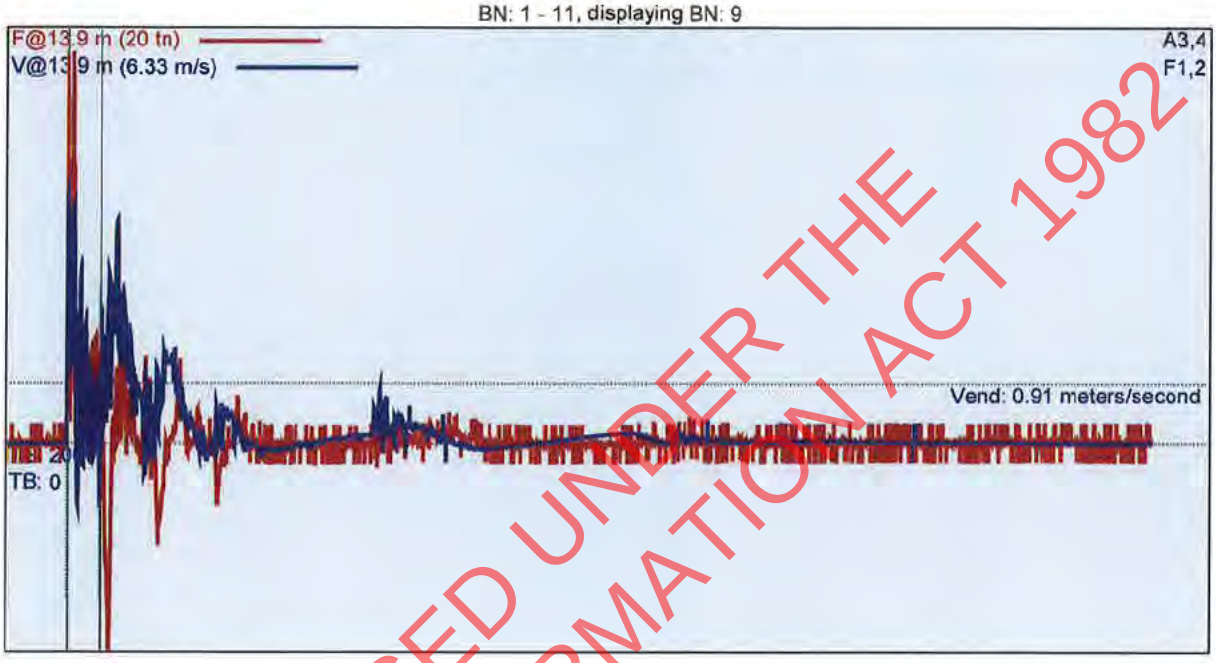
RIG81-
DON
BH-03

12.00
Interval start: 11/03/2021

AR: 7.68 cm^2
LE: 13.9 m
WS: 5123.0 m/s

SP: 7.88 t/m3
EM: 2109 t/cm2

BN: 1 - 11, displaying BN: 9



F1 : [490AWJ1] 206.95 PDICAL (1) FF1
F2 : [490AWJ2] 205.36 PDICAL (1) FF1

A3 (PR): [K10145] 378.155 mv/6.4v/5000g (1) VF1
A4 (PR): [K10144] 362.657 mv/6.4v/5000g (1) VF1

BL#	BC /150mm	LP m	EL m	FMX tn	ETR %	DMX mm	DFN mm	RAT	VMX m/s	CSX MPa	EFV J
1	0	12.00	-12.0	17	80.0	72	72	0.3	3.59	210.9	379
2	0	12.00	-12.0	18	83.3	49	49	0.4	3.73	231.8	395
3	0	12.00	-12.0	18	83.3	40	40	0.3	3.90	225.6	395
4	0	12.00	-12.0	17	82.5	38	38	0.5	3.81	221.6	392
5	0	12.00	-12.0	17	85.1	39	39	0.3	3.68	221.6	404
6	0	12.00	-12.0	17	81.9	34	34	0.5	3.75	218.5	389
7	0	12.00	-12.0	16	83.3	40	40	0.6	3.61	207.6	395
8	0	12.00	-12.0	16	84.2	41	41	0.5	3.58	200.2	400
9	0	12.00	-12.0	19	83.0	29	29	0.8	3.74	236.5	394
10	0	12.00	-12.0	18	82.4	25	25	0.5	3.57	227.0	391
11	0	12.00	-12.0	18	84.8	35	35	0.3	3.48	231.3	402
			Average	17	83.1	40	40	0.5	3.67	221.2	394
			Std Dev	1	1.4	12	12	0.1	0.12	10.6	6
			Maximum	19	85.1	72	72	0.8	3.90	236.5	404
			Minimum	16	80.0	25	25	0.3	3.48	200.2	379
					N-value: 11						

Sample Interval Time: 47.64 seconds

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Summary of SPT Test Results

Project: RIG81-, Test Date: 11/03/2021

FMX: Maximum Force
ETR: Energy Transfer Ratio - Rated
DMX: Maximum Displacement
DFN: Final Displacement

RAT: Length Ratio for SPT
VMX: Maximum Velocity
CSX: Compression Stress Maximum
EFV: Maximum Energy

Instr. Length m	Blows Applied /150mm	Start Depth m	Final Depth m	Start Elev m	Final Elev m	N Value	N60 Value	Average FMX tn	Average ETR %	Average DMX mm	Average DFN mm	Average RAT	Average VMX m/s	Average CSX MPa	Average EFV J
13.9	-1	0.00	0.00	-12.0	-12.0	0	0	17	83.1	40	40	0.5	3.67	221.2	394
							Overall Average Values:	17	83.1	40	40	0.5	3.67	221.2	394
							Standard Deviation:	1	1.4	12	12	0.1	0.12	10.6	6
							Overall Maximum Value:	19	85.1	72	72	0.8	3.90	236.5	404
							Overall Minimum Value:	16	80.0	25	25	0.3	3.48	200.2	379

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Appendix D ScanTec Technical Gravity Survey Report

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Geophysical Survey Technical Report

INTERIM REPORT: Gravity Survey for Auckland Light Rail, Mt Eden and Sandringham Area

Project:	**ALR1116A**
Client:	**Auckland Light Rail**
Location:	**Dominion / Sandringham Rd Area Auckland**
Date:	**March-June 2023**
Technical Staff:	**Matt Watson Paul Vidanovich**
Release Date:	**24/7/23**
Report Reference:	**ALR1116A_GRAV**

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ScanTec
Geophysical Consultants
PO Box 999
Whangarei
NEW ZEALAND
Tel +64 9 436 3966
Tel 021 376 644
info@scantec.co.nz
www.scantec.co.nz

CONTENTS

LIST OF FIGURES

OFFICIAL INFORMATION ACT 1982 RELEASED UNDER THE

1.0 Introduction

ScanTec Ltd was requested by Auckland Light Rail (ALR) to carry out gravity surveys as part of geological/geotechnical investigation associated with the Auckland Light Rail project.

The principal objective of the measurements is to define the extent and thickness of the lava flows. Work is still in progress, and the following is an interim report to advise on survey progress and present the results to date.

Field work, data analysis and 2D gravity modelling was carried out by geophysicists Matt Watson and Paul Vidanovich between March and June 2023.

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2.0 Gravity Survey methodology

2.1 Overview of steps in a gravity survey

A gravity survey is a complex process that involves numerous steps:

Field Work

- Planning gravity station locations and survey layout ahead of the measurements.
- Taking multiple measurements at each station with a gravity meter mainly at night to reduce the effect of traffic vibration on the sensitive spring mechanism within the meter.
- Repeating gravity measurements at a local base station every few hours to monitor and make adjustments for any instrument drift
- Precision surveying using RTK GNSS
- Assessment of the topography immediately around each measurement location, which may involve conventional survey levelling techniques.

Data processing

- corrections for tidal variation, latitude, elevation
- corrections for instrument variation (drift)
- corrections for terrain, which is a complex procedure of dividing the surrounding ground into segments (Hammer Zones). This uses both conventional survey and LiDAR.
- Adjusting the gravity data so that it is tied into the NZ Primary Gravity Network, so that absolute gravity values can be determined. This is done by multiple visits to primary gravity network stations (in the Domain and also Papakura).
- Assessment of the regional gravity field, and in this case acquiring more gravity measurements on basement rock, so that we could create a more accurate map of the Auckland gravity field
- Subtracting the regional gravity field from the Bouguer Anomaly (ie. the processed gravity data) to obtain a residual anomaly which can then be modelled.

Analysis of the data

- Forward modelling of the 2D gravity data, which involves creating a geological model, calculating the gravitational effect of the model, then comparing the resulting gravity anomaly against the observed data to obtain the closest possible curve fit.
- Adjusting the geological model based on borehole data or density information, then repeating the calculations and each time comparing it with the observed data (residual anomaly)
- At the end of the 2D modelling process, the geological model sections are combined into a 3D dataset, from which contour maps can be generated to show the elevation of a specific layer (eg base of basalt, thickness of basalt etc)
- When new geological information is available, the gravity models can be refined (repeating all of the above steps).

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2.2 Data acquisition

A Lacoste and Romberg (L&R) G-*model* gravity meter was used for this survey (Figure 1).

- Approximately 80% of readings were taken at night, to reduce the effects of vibration from traffic noise on the gravity meter.
- Multiple gravity base stations were established and reoccupied at regular intervals during every survey day to monitor and correct for instrument drift.
- Up to 8 readings taken at every station to ensure repeatability and multiple occupancy of stations for quality control.
- Constant temperature regulation is required for the gravity meter. The meter temperature was maintained at 51.7deg C for the entire survey.

Positional surveying was carried out using a RTK GPS (SKYNET, Newmarket base station). Accuracy on stations with acceptable sky coverage was <1cm (horizontal / vertical). Generally measurement locations were selected in locations that provided adequate GPS sky coverage.

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(above) Lacoste and Romberg Model-G, gravity meter (top left). Gravity reading in progress (top right, bottom left). RTK GPS (bottom right)

2.3 Gravity data processing

A combination of custom software (ScanTec Ltd) and QC-TOOL (v5.0) was used for the gravity processing was used for this survey.

Standard gravity corrections were applied to this data set which included;

- Tidal correction
- Instrument drift correction
- Latitude correction
- Free-air correction
- Bouguer correction
- Inner and outer terrain corrections

Notes on Terrain Corrections

One of the most important parts of the gravity survey is the terrain corrections. This involves a very detailed assessment of the topographical variations surrounding the gravity measurement location. The correction accounts for the deviation of the topography from the horizontal slab of infinite extent assumed in the bouguer correction.

Generally the most important consideration is the immediate 30m surrounding the gravity position, but terrain is assessed to 20-30km distance.

For this survey the following techniques were used:

- On site assessment using survey equipment (out to visible distance, or edge of public boundary)
- LiDAR interrogation using Hammer Zones (custom developed software)
- QCTOOL terrain correction module

Data processing for terrain corrections was carried out using custom developed software.

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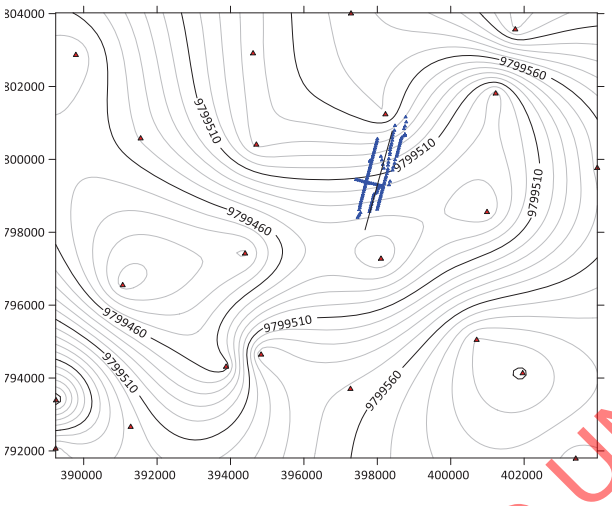
(Above) Arabi A2 is the main gravity base station used for this survey, and is occupied every few hours during each survey day to monitor gravity meter stability and correct for instrument drift. Arabi A2 now has a reliable tie to the NZ Primary Gravity Network.

2.3 Regional Gravity Field

As part of the data processing, the regional gravity field must be subtracted from the bouguer anomaly in order to obtain the residual anomaly, which can then be modelled.

The regional gravity field for the survey area was initially derived using data points in the Auckland gravity database obtained from Reference Gravity Stations (GNS Science, 2023). These gravity data points formed an approximately regular grid across the Auckland region.



(above) initial assessment of the regional field using a selection of the Auckland gravity database.

Following the initial processing and data reduction, it was observed that there were limitations with this assessment of the local regional field, due to the coarse spread of data points used from the GNS gravity database. The initial gravity modelling of the residual was presenting unrealistic forward model solutions, attributed to clearly incorrect regional field assessment.

To correct this issue a new assessment of the regional field was proposed which involved collecting a new independent regional field dataset for use with this survey. After examination of geological maps and other resources, a series of 16 gravity measurements were positioned where East Coast Bays Formation was exposed or relatively shallow lying. Data collection for the new regional field was carried out during early June (see figure below), with gravity readings between Parnell and Mt Albert.

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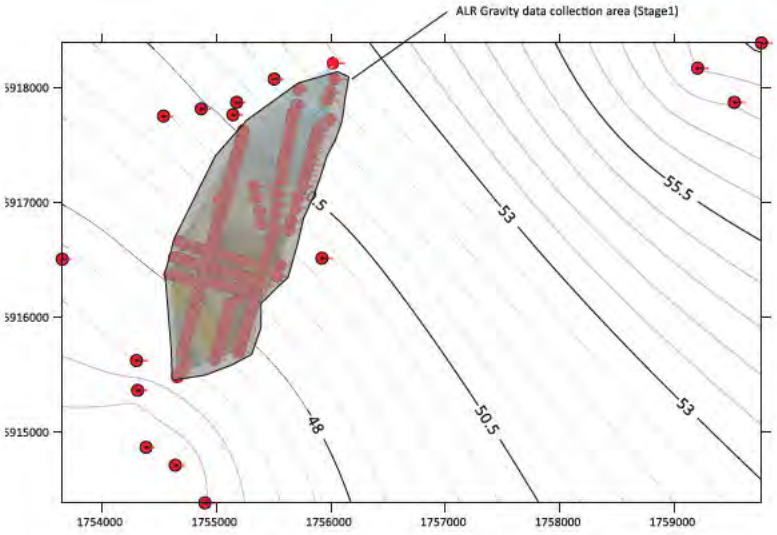
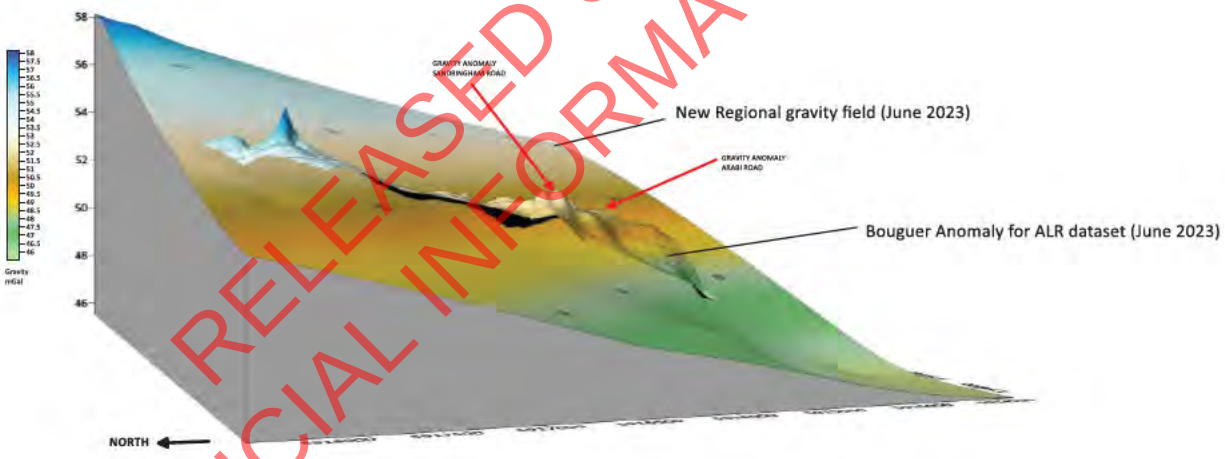


(above) new assessment of the Auckland Regional Gravity Field (June, 2023), using measurements positions selected to be on ECB Formation.



(above) 3D representation of the Auckland Regional Gravity Field (June, 2023), using measurements positions selected to be on ECB Formation.

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2.4 Network tie to the Regional Gravity Network

The ALR gravity survey was tied to the NZ Primary Gravity Network using two stations, Auckland Domain_C66T and Papakura_B3TW.

The tie was carried out using multiple loops in one night shift, between the network stations and three of the local ALR gravity base stations used for this survey.

Both primary network stations were reliably located, and the tie was successfully carried out. Night work was essential, as traffic volumes (trucks) are very high near the Papakura Network gravity station causing gravity meter reading instability.

(above) Gravity readings at Papakura_B3TW primary network station.
This is not an ideal location with heavy truck traffic passing through a nearby roundabout. Readings are only possible late at night.

above) Gravity readings at Auckland Domain primary network station.
Quiet location, although situated on a Watercare Reservoir.

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3.0 Results

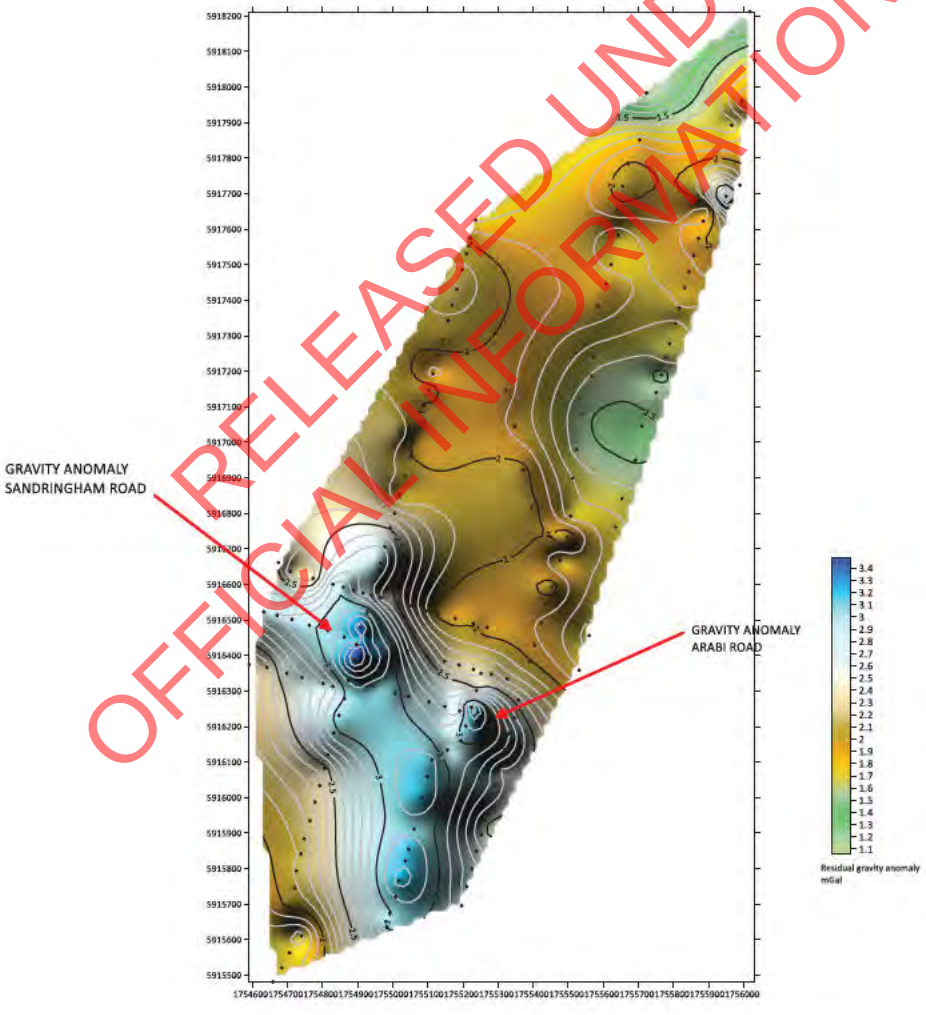
3.1 Location of Gravity Measurements

The location of gravity measurements (stations) in this survey dataset are shown in Figure1 (refer to accompanying A3 figure sheets).

Positional coordinates are provided in Appendix 1 and are provided in both Mt Eden Circuit 2000 and in NZTM. All elevation are provided in NZVD (2016).

3.2 Bouguer Anomaly

The calculated Bouguer Anomaly results are shown as Appendix A1 (values) and as maps (Figures 5 and 6). All GPS coordinates are presented in NZTM. Figure 5 shows a colour contour map. These were generated in SURFER, using kriging gridding technique. No smoothing filters are applied.



RESIDUAL GRAVITY ANOMALY - AREA 1
AUCKLAND LIGHT RAIL GRAVITATIONAL SURVEY, 2023

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General features observed on the residual gravity anomaly map;

- Approximately 3.3mGals range in Bouguer Anomaly is observed across the coverage area
- Gravity anomalies greater than 2.5mGal in magnitude are observed in the southern section of the dataset
- Lowest gravity anomaly values in the northern and eastern sections of the dataset

3.4 2D Gravity profiles and models

2D forward modelling has carried out on this data using GM-SYS software (Northwest Geophysical Associates Ltd).

The results are presented as figures 4 to 10.

Figure 4 – Gravity Line 1, Marlborough Ave
Figure 5 – Gravity Line 2, Eden Park
Figure 6 – Gravity Line 3, Sandringham Road
Figure 7 – Gravity Line 4, Balmoral Road
Figure 8 – Gravity Line 5, Arabi Street
Figure 9 – Gravity Line 6, Watson Ave
Figure 10 – Gravity Line 7, Patterson Ave

Parameters: Iteration 1 = simple 3 layer case.
Density: Basalt = 2.7g/cc, Weathered ECB = 1.8g/cc, ECB = 2.2g/cc

Modelling of gravity data generally requires the use of additional geological data (field mapping, borehole logs, other geophysical data). However in the first instance, no borehole control was used for the initial model iteration – just a simple 3 layer model with standard density values. This is to assess the gravity data, without involving a complex geological model. The gravitational effect of this model is then calculated and compared against the observed gravity data, with the objective of obtaining as close a fit as possible.

The next iteration of the modelling will use a geological section based on external control data, borehole logs, downhole geophysical logs, core sampling (eg. density).

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3.5 Lava flow thickness based on gravity models (3D representation)

The 2D gravity model sections were merged into a 3D database and contour maps generated.

The depth to the base of the basalt lava (gravity model) is shown in Figure 11.

Thickness of the basalt lava is indicated in Figure 12.

At present, the trends in basalt thickness are being indicated by the gravity method, without external control (boreholes), and using simplified density information. This can be seen in comparison with borehole information provided in the FLOOK dataset. *(see Figure 12, comparison between borehole logs and gravity model v5.0).*

In some areas the gravity model is very close to the actual basalt thickness as determined through drilling information. In other areas, such as Balmoral/Arabi/Sandringham, the gravity model is currently over-estimating the basalt thickness.

Geophysical analysis / modelling tasks in progress include;

- Assessment of density structure of basalt using geophysical logs
- Using the new density model in GM-SYS, to refine the thickness of the basalt.
- Using lab test results on drilling core for density of basalt

Following the above steps, the resulting gravity model should converge with the actual geological structure.

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4.0 Summary

Gravity measurements have been carried out in the Sandringham / Mt Eden areas during March – June 2023, to assist with the geotechnical investigation for the Auckland Light Rail project.

The gravity survey consisted of a series of 7 individual measurement lines (transects).
A 2D gravity model has been prepared for each of the lines, initially using no drillhole control (Gravity Model v5.0), as an independent comparison to the existing geological model. The final output consists of a series of 2D geological models. The 2D lines were then merged into a 3D dataset to show as a contour map of base of basalt and isopach (thickness) image.

Additional regional gravity measurements were required to provide a clear unde standing of the regional gravity field in the Mt Eden/Sandringham area and increased accuracy in the residual bouguer anomalies.

Analysis and gravity modelling is ongoing, with the current emphasis on refining the density of the geological formations within the gravity model, based on geophysical logs and drilling core data.

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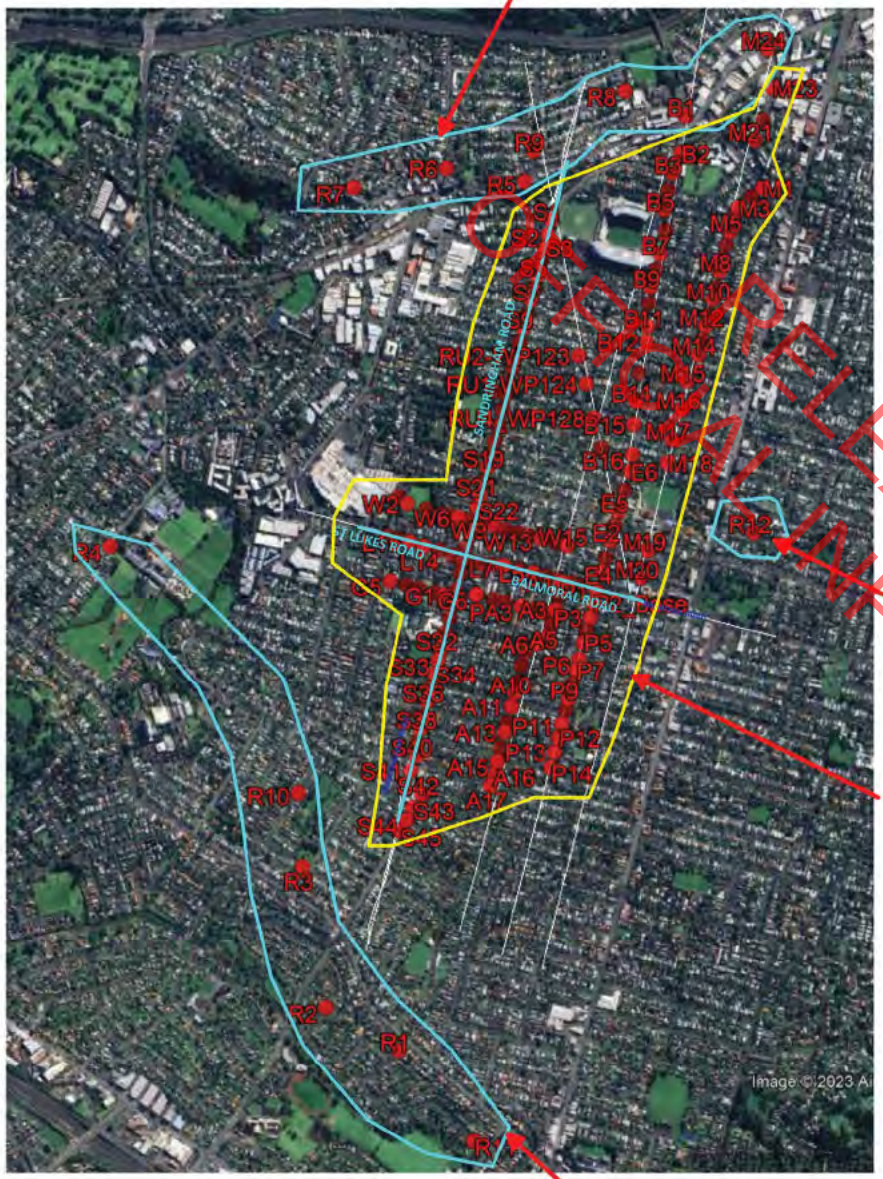
Please let me know if you have any questions relating to this technical report.

Matt Watson (MSc)
Geophysicist / Director
ScanTec Ltd
matt@scantec.co.nz
s 9(2)(a)



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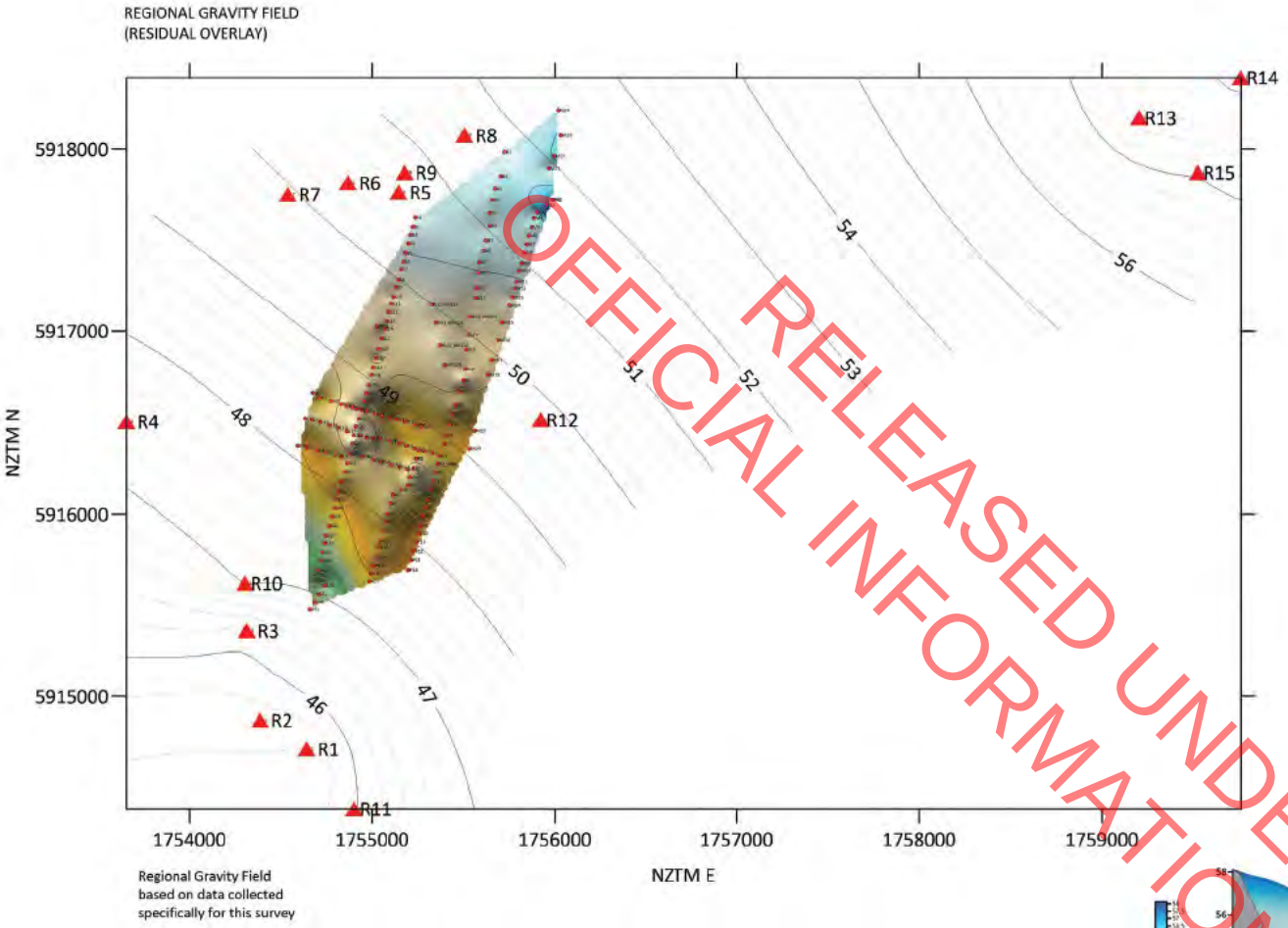
ScanTec
Geophysical Consultants
PO Box 999
Whangarei
NEW ZEALAND
Tel +64 9 436 3966
Tel 021 376 644
info@scantec.co.nz
www.scantec.co.nz

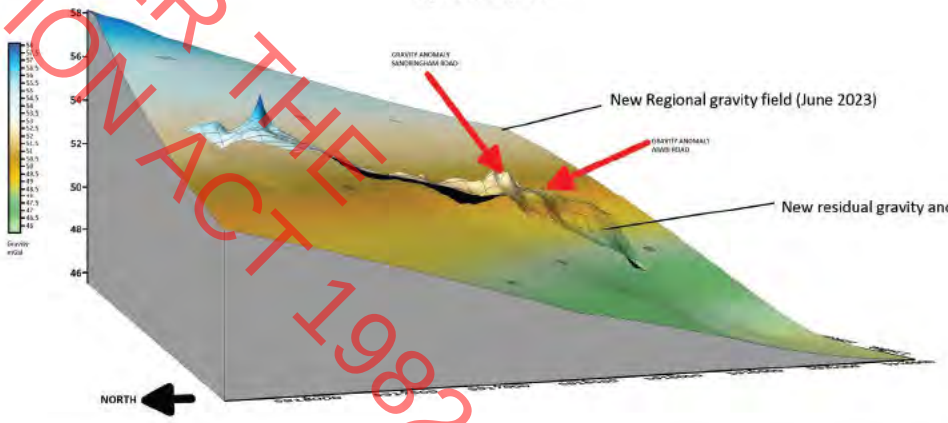
CLIENT	Auckland Light Rail (ALR)
PROJECT	Gravity Survey - ALR Part 1
DATE	March-June 2023
PERSONNEL	MW / PV
EQUIPMENT	L&R Model-G Gravity Meter. RTK GNSS
CONTACT 1	matt@scantec.co.nz
CONTACT 2	021-376-644

Figure 1 - Gravity Survey Locations March - June 2023



Regional Gravity Field
based on data collected
specifically for this survey

3D representation of
Regional Gravity Field



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ScanTec
Geophysical Consultants
PO Box 999
Whangarei
NEW ZEALAND
Tel +64 9 436 3966
Tel 021 376 644
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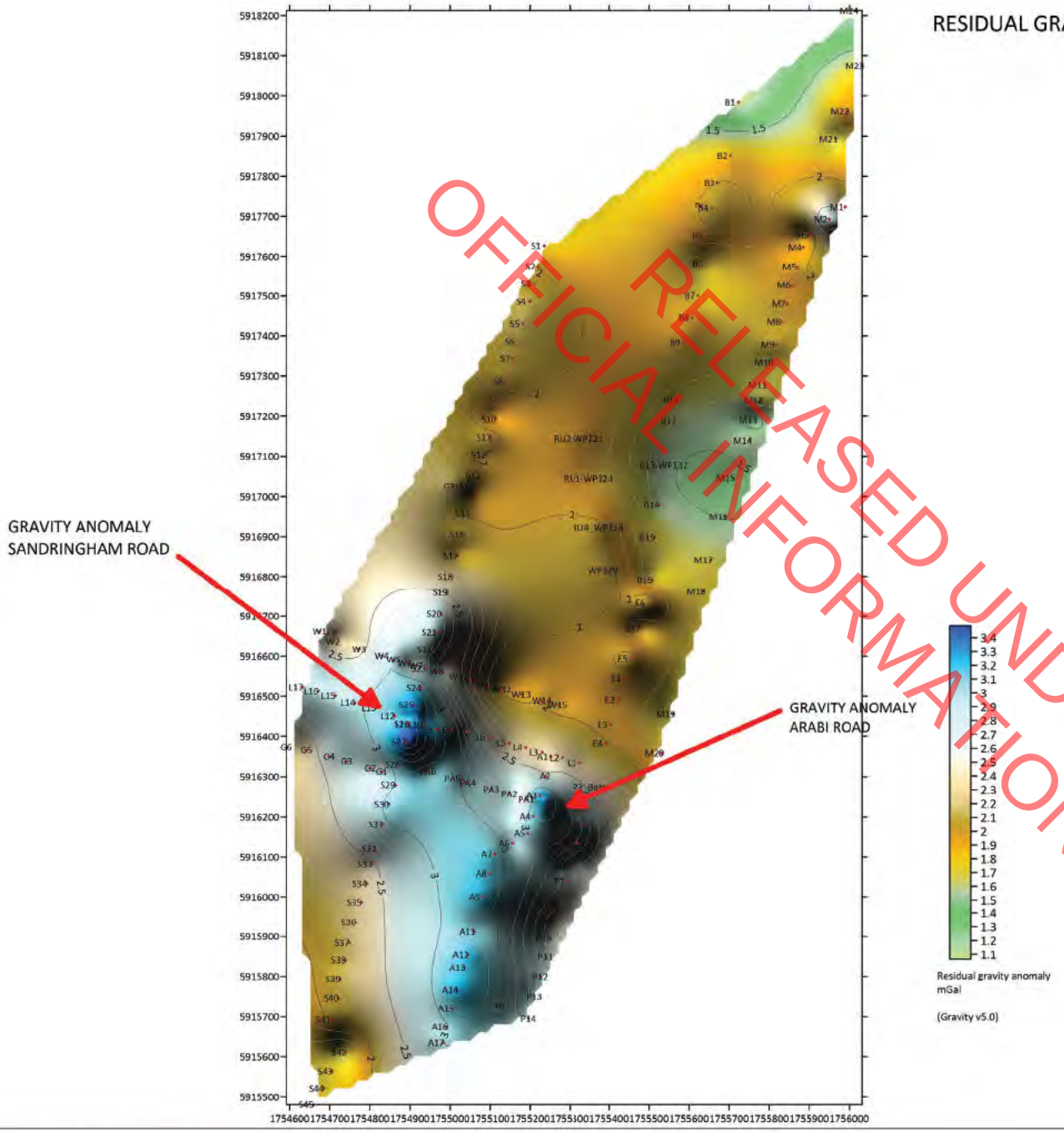
Figure 2 - Regional Gravity Field Measurement

RESIDUAL GRAVITY ANOMALY - AREA 1



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Geophysical Consultants
PO Box 999
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NEW ZEALAND
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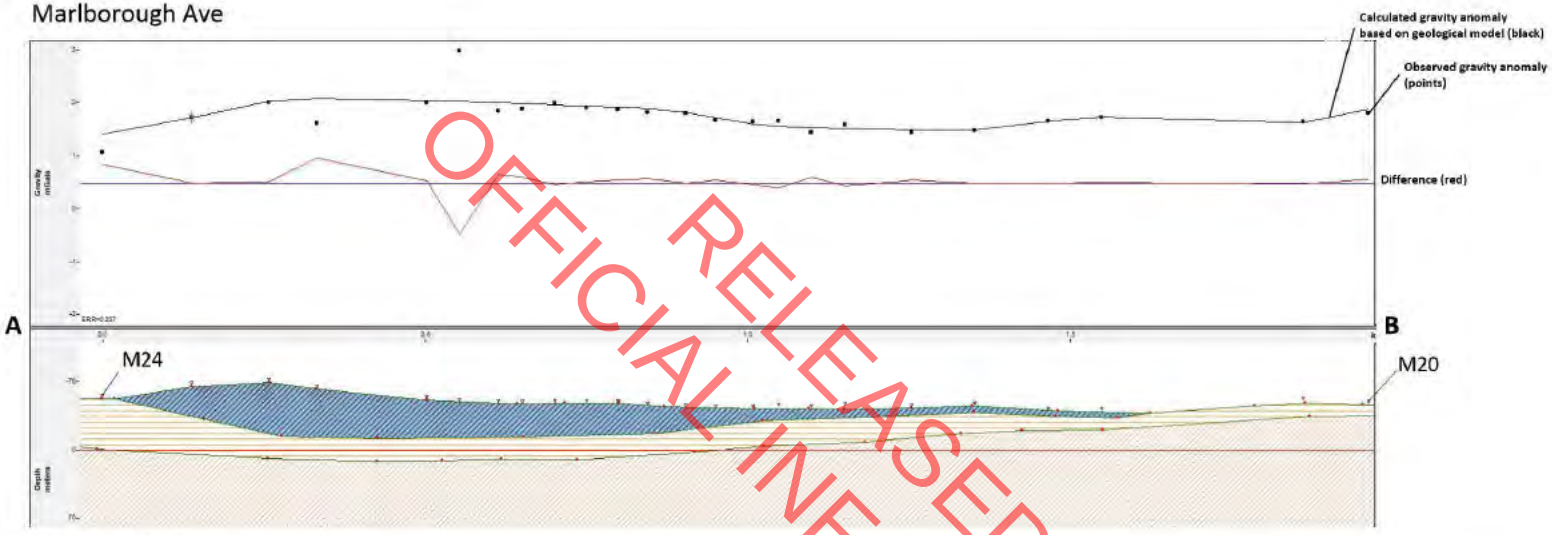
Figure 3 - Residual Gravity Anomaly

Gravity Line 1
Marlborough Ave



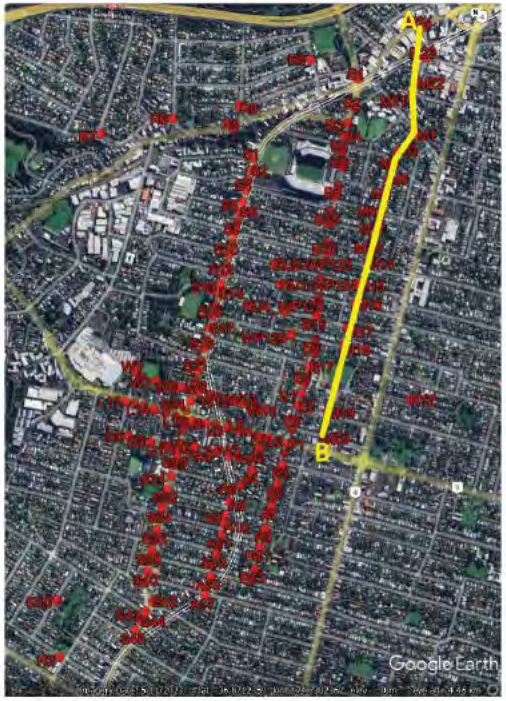
GMSYS MODEL DATA

Sta# (old)	X (km)	Z (meters)	Obs. (mGals)	Calc. + DC (mGals)
1 (1)	0.000	-54.717	1.064	1.410
2 (2)	0.138	-66.468	1.729	1.729
3 (3)	0.267	-70.450	2.002	2.034
4 (4)	0.332	-63.113	1.823	2.088
5 (5)	0.503	-53.049	2.006	2.048
6 (6)	0.552	-49.630	2.093	2.028
7 (7)	0.613	-48.780	1.849	2.008
8 (8)	0.658	-48.050	1.884	1.992
9 (9)	0.701	-48.830	1.997	1.967
10 (10)	0.751	-48.500	1.911	1.942
11 (11)	0.798	-48.290	1.875	1.924
12 (12)	0.844	-46.270	1.814	1.896
13 (13)	0.904	-44.440	1.809	1.812
14 (14)	0.956	-43.840	1.672	1.722
15 (15)	1.008	-43.770	1.639	1.618
16 (16)	1.048	-44.940	1.859	1.567
17 (17)	1.099	-43.570	1.438	1.539
18 (18)	1.151	-45.360	1.584	1.525
19 (19)	1.254	-44.370	1.446	1.501
20 (20)	1.352	-46.870	1.488	1.498
21 (21)	1.466	-48.680	1.668	1.657
22 (22)	1.549	-48.830	1.725	1.736
23 (23)	1.863	-50.650	1.645	1.625
24 (24)	1.965	-47.700	1.809	1.803

2D Gravity Model

Model Version: G.Model v5.0, June 2023

Station	NZTM E	NZTM N	NZVD2016
M24	1756017.05	5918212.14	54.717
M23	1756031.16	5918074.65	65.7
M22	1755994.05	5917961.53	68.7
M21	1755965.47	5917892.49	66.9
M1	1755988.97	5917723.58	53.049
M2	1755949.69	5917692.76	49.63
M3	1755902.33	5917655.5	48.78
M4	1755884.63	5917622.49	48.05
M5	1755870.75	5917573.72	48.83
M6	1755856.83	5917526.05	48.5
M7	1755844.47	5917479.95	48.29
M8	1755832.11	5917435.54	46.27
M9	1755816.48	5917378.2	44.44
M10	1755804.47	5917333.71	43.04
M11	1755788.34	5917277.7	43.77
M12	1755778.35	5917239.34	44.94
M13	1755765.01	5917190.23	43.57
M14	1755750.9	5917139.67	45.36
M15	1755708.89	5917045.73	44.37
M16	1755691.14	5916949.61	46.07
M17	1755652.81	5916841.98	40.6
M18	1755634.97	5916761.18	40.83
M19	1755559.41	5916455.86	50.65
M20	1755530.93	5916358.56	47.7



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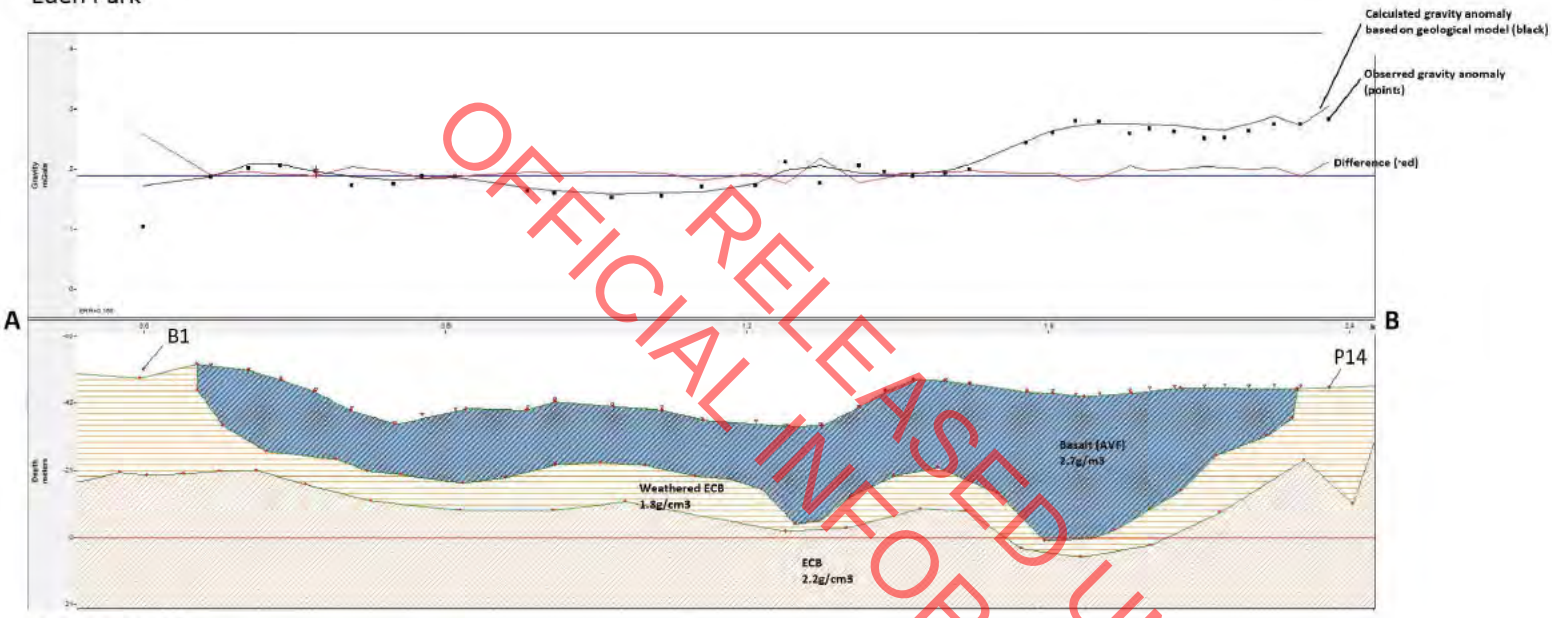
ScanTec
Geophysical Consultants
PO Box 999
Whangarei
NEW ZEALAND
Tel +64 9 436 3966
Tel 021 376 644
info@scantec.co.nz
www.scantec.co.nz

CLIENT Auckland Light Rail (ALR)
PROJECT Gravity Survey - ALR Part 1
DATE March-June 2023
PERSONNEL MW / PV
EQUIPMENT L&R Model-G Gravity Meter. RTK GNSS

CONTACT 1 matt@scantec.co.nz
CONTACT 2 021-376-644

Figure 4 - Gravity Line 1

Gravity Line 2
Eden Park



2D Gravity Model

Model Version: G.Model v5.0, June 2023

GMSYS MODEL DATA

Stat (old)	X (km)	Z (meters)	Obs. (mGals)	Calc. + DC (mGals)
1 (1)	0.000	-51.939	1.046	1.734
2 (2)	0.134	-53.672	1.071	1.881
3 (3)	0.269	-51.987	2.016	2.086
4 (4)	0.272	-49.384	2.055	2.078
5 (5)	0.342	-45.875	1.967	1.967
6 (6)	0.414	-48.066	1.724	1.878
7 (7)	0.490	-35.375	1.758	1.823
8 (8)	0.555	-37.944	1.886	1.847
9 (9)	0.620	-39.780	1.877	1.867
10 (10)	0.763	-40.220	1.637	1.692
11 (11)	0.817	-42.780	1.594	1.641
12 (12)	0.931	-41.200	1.523	1.582
13 (13)	1.020	-40.210	1.557	1.609
14 (14)	1.112	-36.430	1.708	1.626
15 (15)	1.216	-35.978	1.738	1.768
16 (16)	1.278	-34.580	2.124	1.990
17 (17)	1.347	-34.980	1.769	2.064
18 (18)	1.424	-40.480	2.058	1.937
19 (19)	1.475	-45.537	1.953	1.921
20 (20)	1.531	-48.860	1.883	1.927
21 (21)	1.596	-48.984	1.926	1.981
22 (22)	1.644	-47.985	2.005	2.085
23 (23)	1.758	-45.580	2.442	2.477
24 (24)	1.809	-45.316	2.609	2.651
25 (25)	1.856	-44.287	2.805	2.720
26 (26)	1.902	-44.512	2.784	2.758
27 (27)	1.963	-45.576	2.591	2.762
28 (28)	2.002	-46.347	2.672	2.750
29 (29)	2.051	-46.786	2.628	2.732
30 (30)	2.111	-47.010	2.511	2.670
31 (31)	2.151	-47.046	2.522	2.659
32 (32)	2.200	-46.980	2.645	2.754
33 (33)	2.251	-47.070	2.743	2.889
34 (34)	2.303	-46.982	2.745	2.735
35 (35)	2.359	-46.577	2.928	3.066

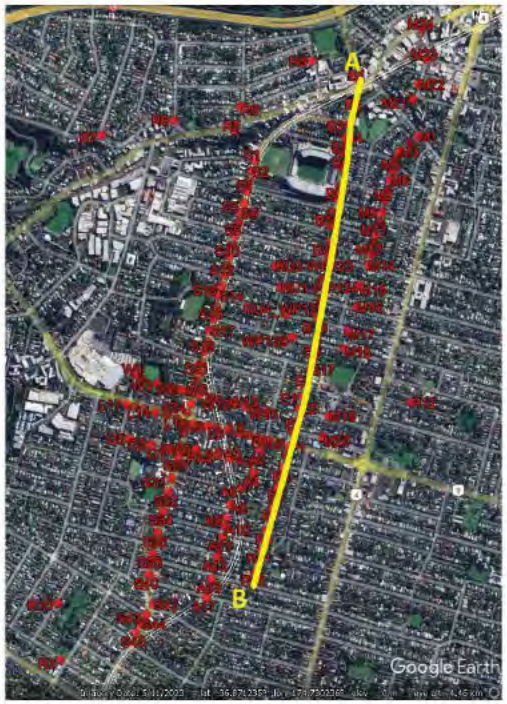


Figure 5 - Gravity Line 2

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Tel +64 9 436 3966
Tel 021 376 644
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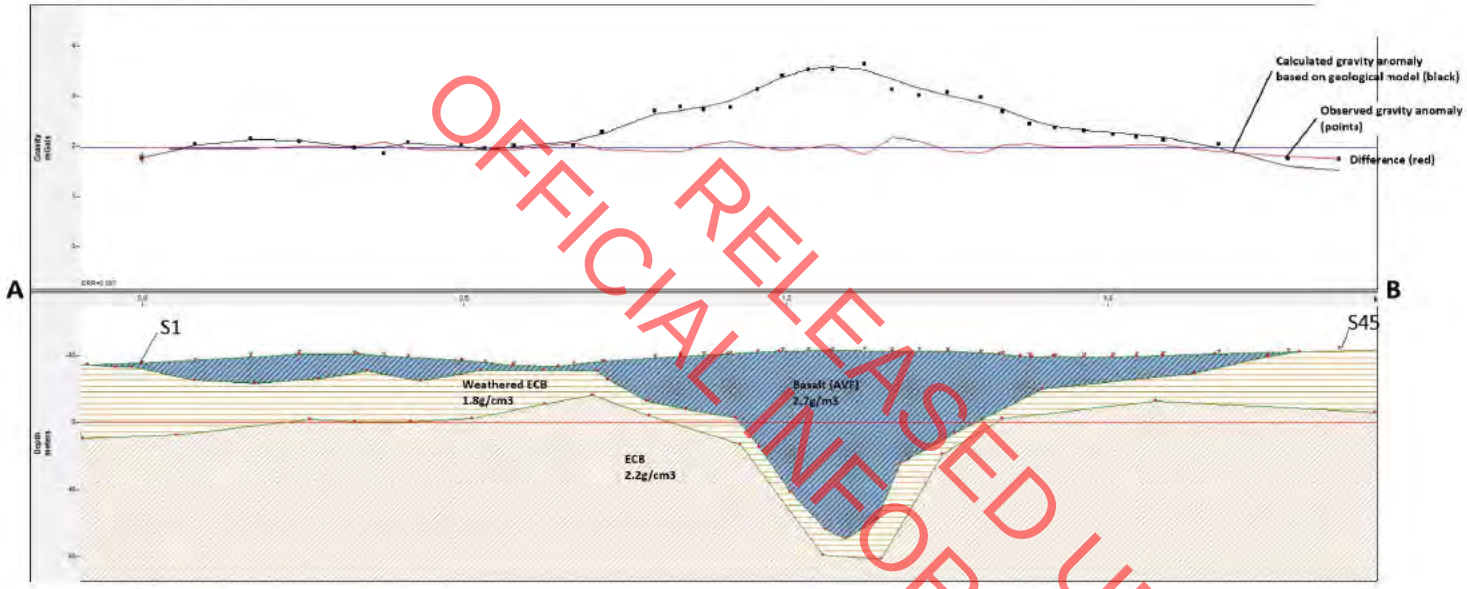
CONTACT 1	matt@scantec.co.nz
CONTACT 2	021-376-644

Gravity Line 3
Sandringham Road



2D Gravity Model

Model Version: G.Model v5.0, June 2023

GMSYS MODEL DATA

Stat# (old)	X [km]	Z [meters]	Obs [mGals]	Calc + DC [mGals]
1 (1)	0.001	-34.944	1.765	1.765
2 (2)	0.108	-36.395	2.037	2.022
3 (3)	0.263	-39.862	2.148	2.136
4 (4)	0.294	-41.262	2.089	2.121
5 (5)	0.356	-40.725	1.965	1.975
6 (6)	0.458	-39.439	1.852	1.983
7 (7)	0.497	-38.624	2.078	2.068
8 (8)	0.595	-36.296	2.024	1.985
9 (9)	0.639	-35.122	1.952	1.928
10 (10)	0.694	-34.393	2.085	1.978
11 (11)	0.804	-34.273	1.998	2.103
12 (12)	0.858	-35.419	2.274	2.244
13 (13)	0.956	-38.588	2.701	2.646
14 (14)	1.004	-39.722	2.789	2.719
15 (15)	1.048	-40.296	2.727	2.783
16 (16)	1.097	-40.836	2.770	2.911
17 (17)	1.147	-41.331	3.120	3.153
18 (18)	1.194	-42.669	3.409	3.373
19 (19)	1.243	-42.888	3.527	3.531
20 (20)	1.287	-43.045	3.523	3.587
21 (21)	1.347	-43.399	3.641	3.515
22 (22)	1.399	-42.900	3.119	3.332
23 (23)	1.449	-42.858	3.005	3.147
24 (24)	1.501	-42.884	3.071	3.017
25 (25)	1.564	-41.720	2.970	2.864
26 (26)	1.604	-40.644	2.683	2.748
27 (27)	1.655	-39.409	2.445	2.534
28 (28)	1.702	-38.973	2.361	2.382
29 (29)	1.757	-39.249	2.383	2.316
30 (30)	1.810	-39.542	2.233	2.269
31 (31)	1.854	-39.797	2.176	2.232
32 (32)	1.904	-40.377	2.120	2.179
33 (33)	2.007	-41.661	2.028	1.968
34 (34)	2.137	-42.248	1.756	1.597
35 (35)	2.231	-43.556	1.736	1.523

Figure 6 - Gravity Line 3

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Geophysical Consultants
PO Box 999
Whangarei
NEW ZEALAND
Tel +64 9 436 3966
Tel 021 376 644
info@scantec.co.nz
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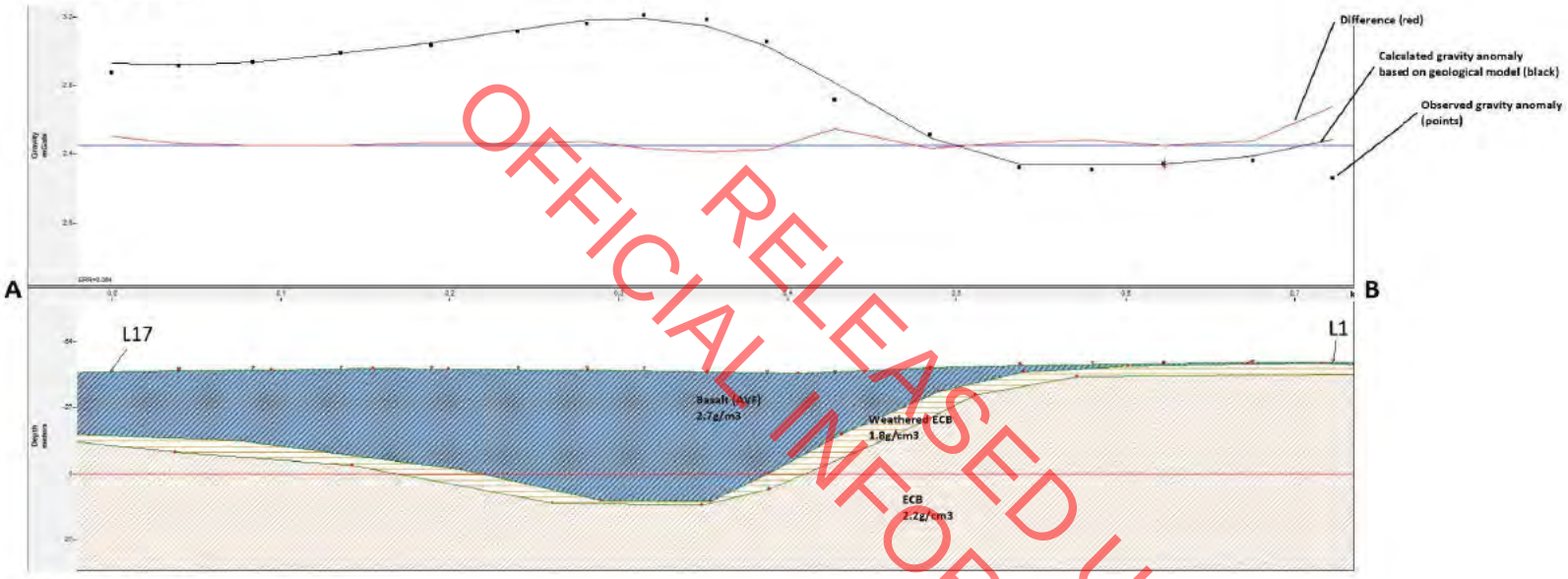
EQUIPMENT L&R Model-G Gravity Meter. RTK GNSS

CONTACT 1 matt@scantec.co.nz
CONTACT 2 021-376-644

Gravity Line 4
Balmoral Road

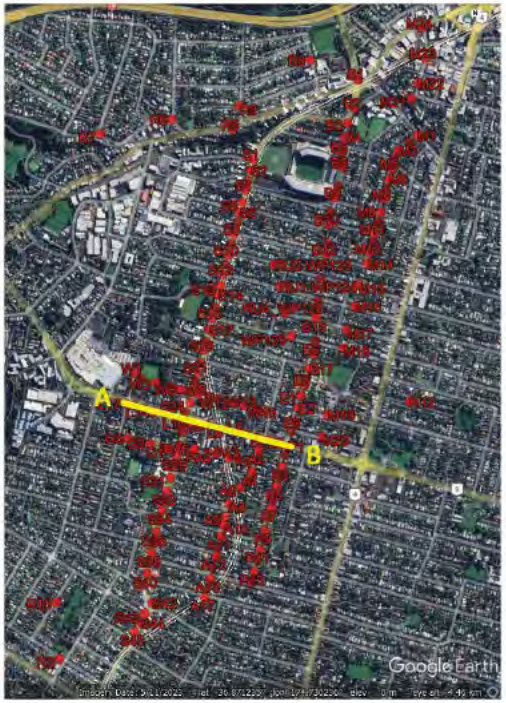


2D Gravity Model

Model Version: G.Model v5.0, June 2023

GMSYS MODEL DATA

Stat# (old)	X (Km)	Z (meters)	Obs. (mGals)	Calc. + DC (mGals)
1 (1)	0.000	-41.369	2.874	2.928
2 (2)	0.040	-42.460	2.913	2.924
3 (3)	0.084	-42.829	2.934	2.934
4 (4)	0.136	-42.942	2.987	2.988
5 (5)	0.189	-42.907	3.033	3.050
6 (6)	0.240	-42.865	3.115	3.127
7 (7)	0.281	-42.864	3.158	3.182
8 (8)	0.315	-42.493	3.206	3.192
9 (9)	0.353	-41.505	3.182	3.145
10 (10)	0.389	-41.225	3.051	3.026
11 (11)	0.428	-41.301	2.716	2.815
12 (12)	0.484	-42.700	2.518	2.496
13 (13)	0.537	-44.726	2.319	2.339
14 (14)	0.580	-45.027	2.309	2.340
15 (15)	0.623	-45.136	2.349	2.340
16 (16)	0.676	-45.500	2.360	2.388
17 (17)	0.723	-45.723	2.260	2.489



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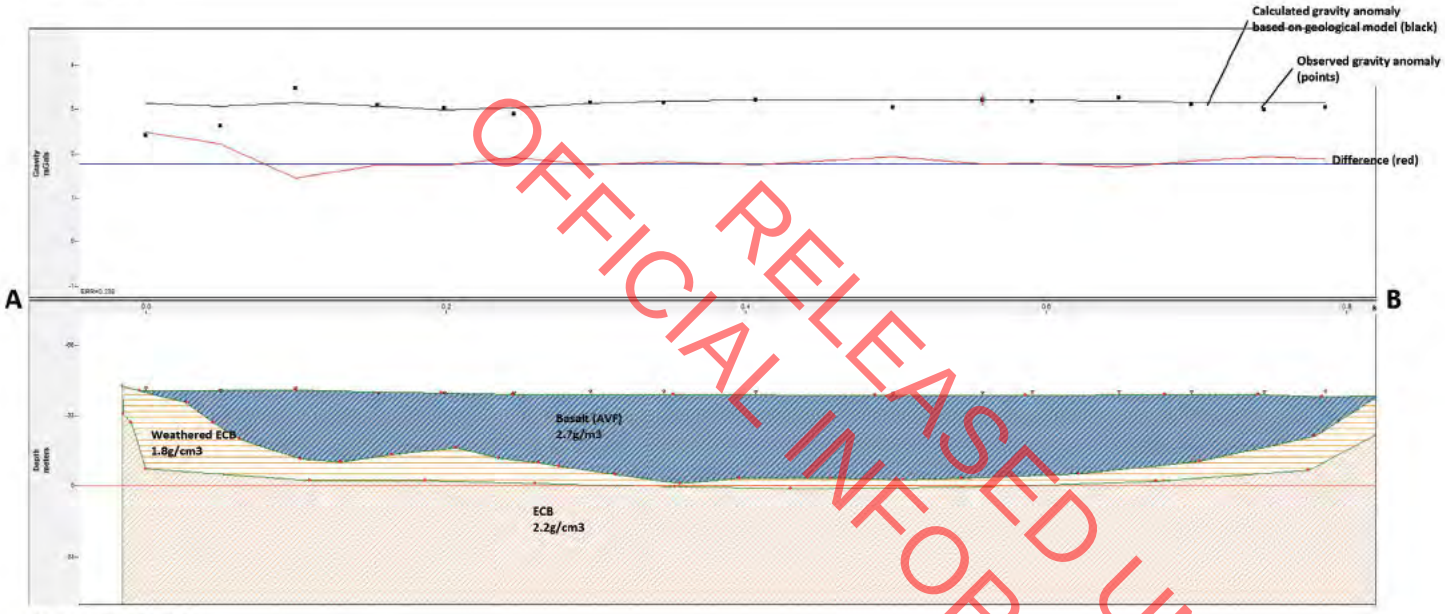
ScanTec
Geophysical Consultants
PO Box 999
Whangarei
NEW ZEALAND
Tel +64 9 436 3966
Tel 021 376 644
info@scantec.co.nz
www.scantec.co.nz

CLIENT Auckland Light Rail (ALR)
PROJECT Gravity Survey - ALR Part 1
DATE March-June 2023
PERSONNEL MW / PV
EQUIPMENT L&R Model-G Gravity Meter. RTK GNSS

CONTACT 1 matt@scantec.co.nz
CONTACT 2 021-376-644

Figure 7 - Gravity Line 4

Gravity Line 5
Arabi Road



2D Gravity Model

Model Version: G.Model v5.0, June 2023

GMSYS MODEL DATA

Stat# (old)	X [Km]	Z [meters]	Obs. [mGals]	Calc. + DC. [mGals]
1 [1]	0.000	-45.818	2.415	3.126
2 [2]	0.050	-43.574	2.618	3.064
3 [3]	0.100	-45.040	3.470	3.151
4 [4]	0.154	-43.000	3.080	3.065
5 [5]	0.199	-42.869	3.011	2.986
6 [6]	0.245	-42.900	2.883	3.034
7 [7]	0.296	-43.717	3.139	3.130
8 [8]	0.346	-43.530	3.145	3.198
9 [9]	0.407	-43.216	3.213	3.203
10 [10]	0.458	-42.529	3.039	3.205
11 [11]	0.558	-43.010	3.209	3.209
12 [12]	0.591	-43.102	3.183	3.206
13 [13]	0.649	-43.154	3.253	3.188
14 [14]	0.697	-43.303	3.105	3.168
15 [15]	0.745	-43.300	2.987	3.145
16 [16]	0.786	-43.609	3.032	3.158

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CONTACT 1: matt@scantec.co.nz
CONTACT 2: 021-376-644

Figure 8 - Gravity Line 5

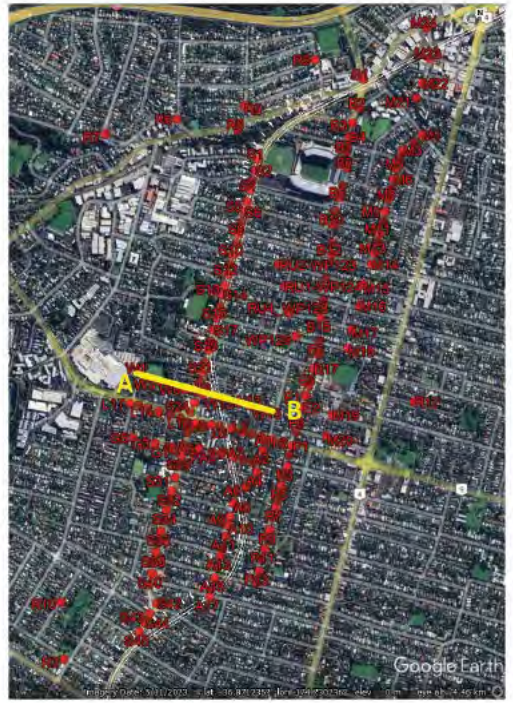
Gravity Line 6
Watson Road

2D Gravity Model

Model Version: G.Model v5.0, June 2023

GMSYS MODEL DATA

Stat# [old]	X [km]	Z [meters]	Obs. [mGals]	Calc. + DC [mGals]
1 [1]	0.000	-35.726	2.543	2.623
2 [2]	0.042	-35.558	2.321	2.384
3 [3]	0.110	-35.866	2.351	2.376
4 [4]	0.169	-41.427	2.913	2.927
5 [5]	0.280	-42.073	2.997	2.997
6 [6]	0.229	-41.171	2.856	2.953
7 [7]	0.258	-40.963	2.748	2.821
8 [8]	0.311	-40.889	2.564	2.591
9 [9]	0.362	-41.638	2.483	2.457
10 [10]	0.399	-41.971	2.290	2.338
11 [11]	0.446	-42.937	2.092	2.131
12 [12]	0.480	-43.395	1.960	1.985
13 [13]	0.530	-43.482	1.950	1.980
14 [14]	0.584	-44.630	2.000	2.010
15 [15]	0.625	-46.903	1.935	1.991



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CONTACT 2 021-376-644

Figure 9 - Gravity Line 6

Gravity Line 7
Patterson Road

GMSYS MODEL DATA

Stat# (old)	X [km]	Z [meters]	Obs. [mGals]	Calc. + DC. [mGals]
1 (1)	0.000	-36.258	2.229	2.526
2 (2)	0.051	-38.489	2.345	2.367
3 (3)	0.110	-41.704	2.636	2.583
4 (4)	0.155	-42.149	2.674	2.689
5 (5)	0.217	-42.493	2.777	2.820
6 (6)	0.246	-42.708	2.838	2.866
7 (7)	0.362	-43.312	3.027	3.027
8 (8)	0.426	-42.877	3.060	3.022
9 (9)	0.465	-42.570	2.932	2.939
10 (10)	0.526	-43.688	2.845	2.812
11 (11)	0.573	-44.840	2.763	2.753
12 (12)	0.617	-44.929	2.734	2.807

2D Gravity Model

Model Version: G.Model v5.0, June 2023

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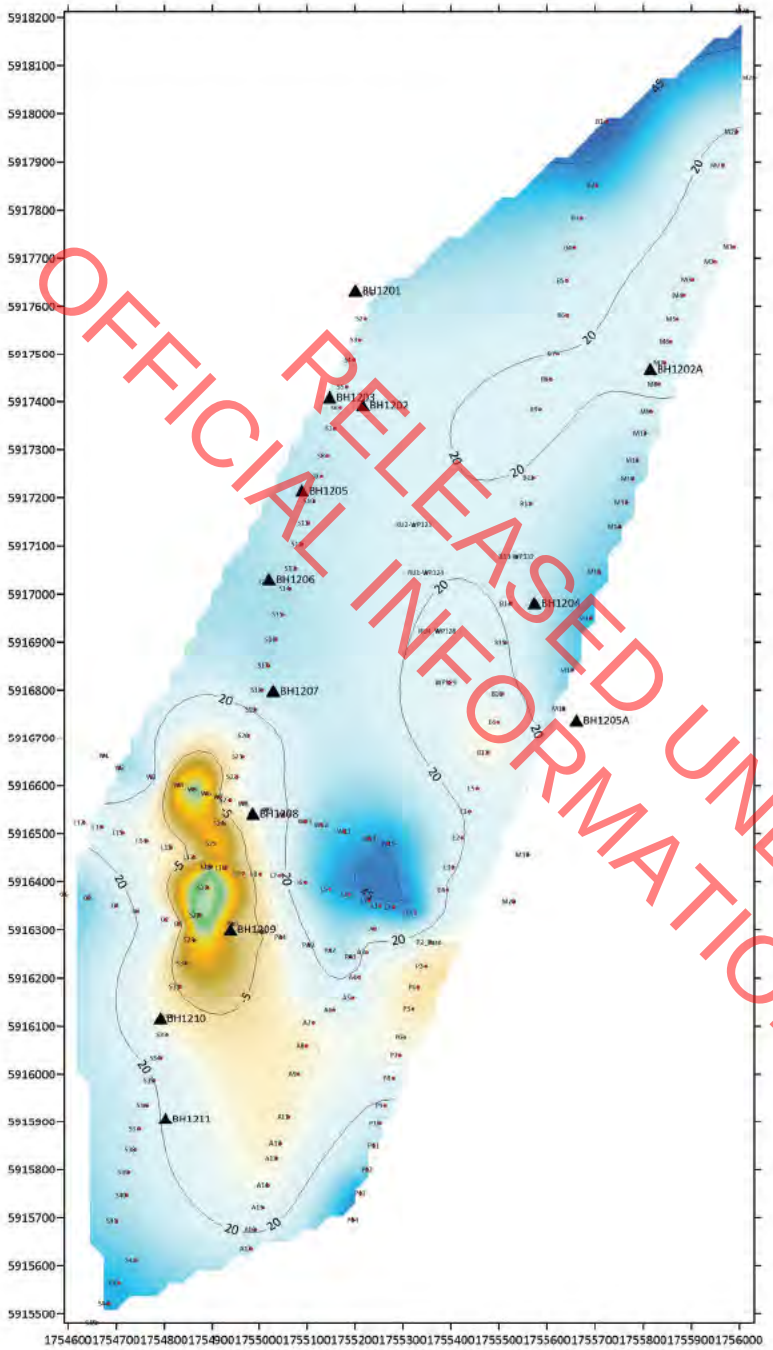
CONTACT 2	021-376-644

Figure 10 - Gravity Line 7

ESTIMATED BASALT THICKNESS FROM GRAVITY MEASUREMENTS
NO BOREHOLE CONTROL USED



Base of basalt
ALR Gravity Model 5.0
Elevation (metres)
NZVD 2016

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Figure 11 - Base of Basalt Gravity Model v5.0

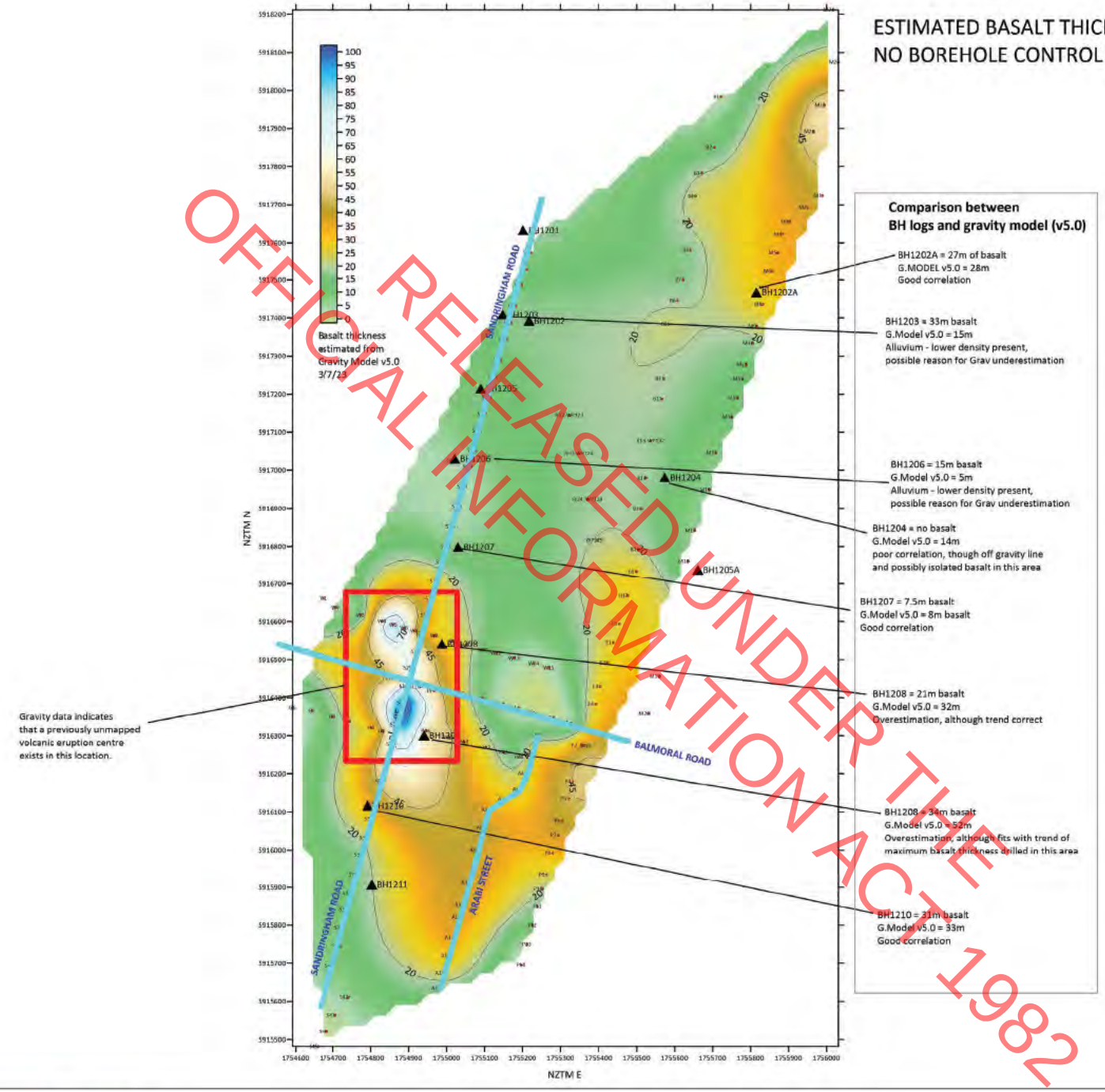

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Figure 12 - Basalt Thickness estimate Gravity Model v5.0