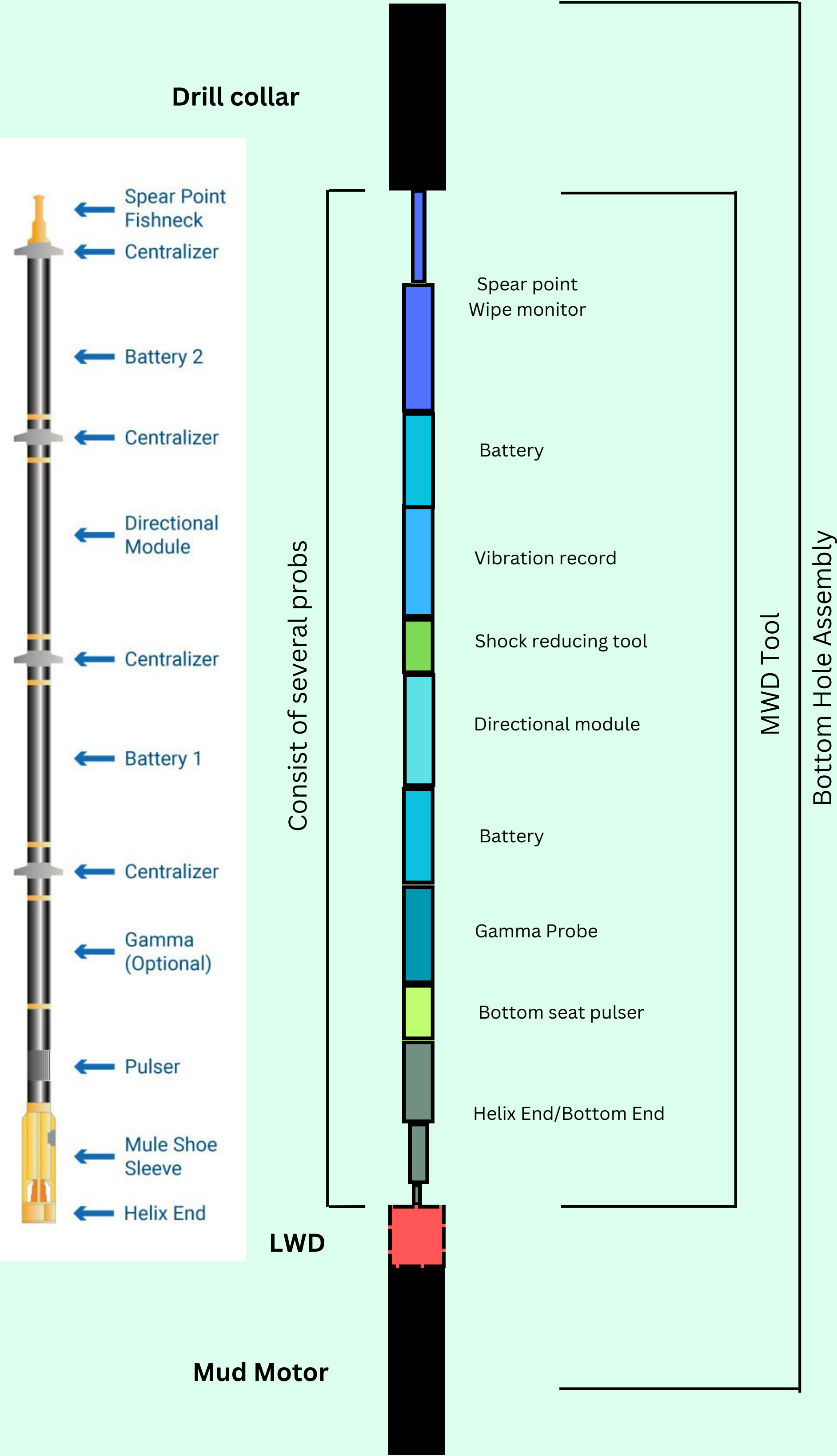


Measurement While Drilling (MWD)

Function: Borehole direction, formation properties and drilling performance (Directional Module).

(MWD) TOOL - Positive pulse



Notes:

- The MWD probs can be changed, reorder, add, depends on type of the MWD Tool.
- An important tool in directional drilling.

Information we can get from the MWD tool:

Directional data:

- Azimuth (horizontal direction) and inclination (vertical angle) of the wellbore.

Drilling parameters:

- Weight on bit (WOB).
- Rotary speed.
- Torqu.
- Mud flow rate.

Formation evaluation:

- Properties of the rock formations:
- 1- resistivity.
 - 2- gamma ray.
 - 3- porosity.
 - 4- etc...

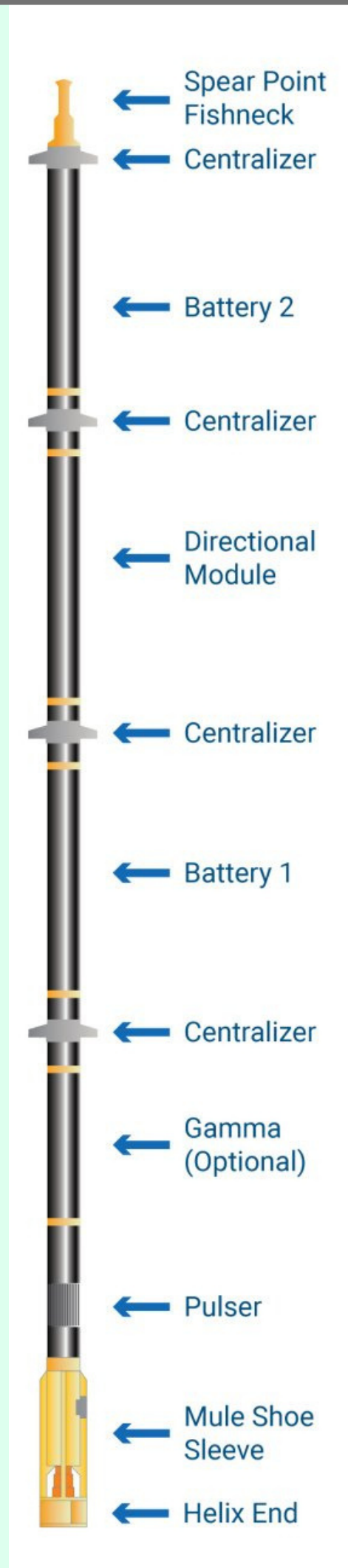
Shock and vibration data:

- Measure the shock and vibration experienced by the drillstring during drilling.

(MWD) Components

Three main components: Power Supply, Sensor Section & Transmitter.

Positive Pulse MWD



Power Supply:

- Battery & Turbine.

Sensor Section:

- Magnetometers: Three magnetic sensors 90 degrees (BX- BY- BZ). Measuring Earth's magnetic field.
- Accelerometers: (Three sensors 90 degree (AX- AY- AZ). Measuring Earth's gravity field.
- Other sensors such as pressure, gamma-ray, and resistivity are typically housed in separate dedicated tool sections.

Transmitter:

Two Basic ways

- **(Common)**Telemetry pulse (Negative, positive and continues pulse).
- Electromagnetic (EM)

Other components.

• Lower Bottom end:

(Generate pulse by restricting flow).

• Shock reducing tool:

Reduce axial and vibration up to 40%

• Bottom seat pulser:

Control flow and restriction mud.

• Gamma Probe:

Measure nature gamma ray.

• Directional module:

Accelerometers & Accelerometers.

• Vibration sensor:

Record shock and vibration.

• Wipe monitor/Spear point:

Pick up and lay down tool with an overshot tool. Fishing operation.

• Ctabilazer:

ALL COMPONENTS OF MWD

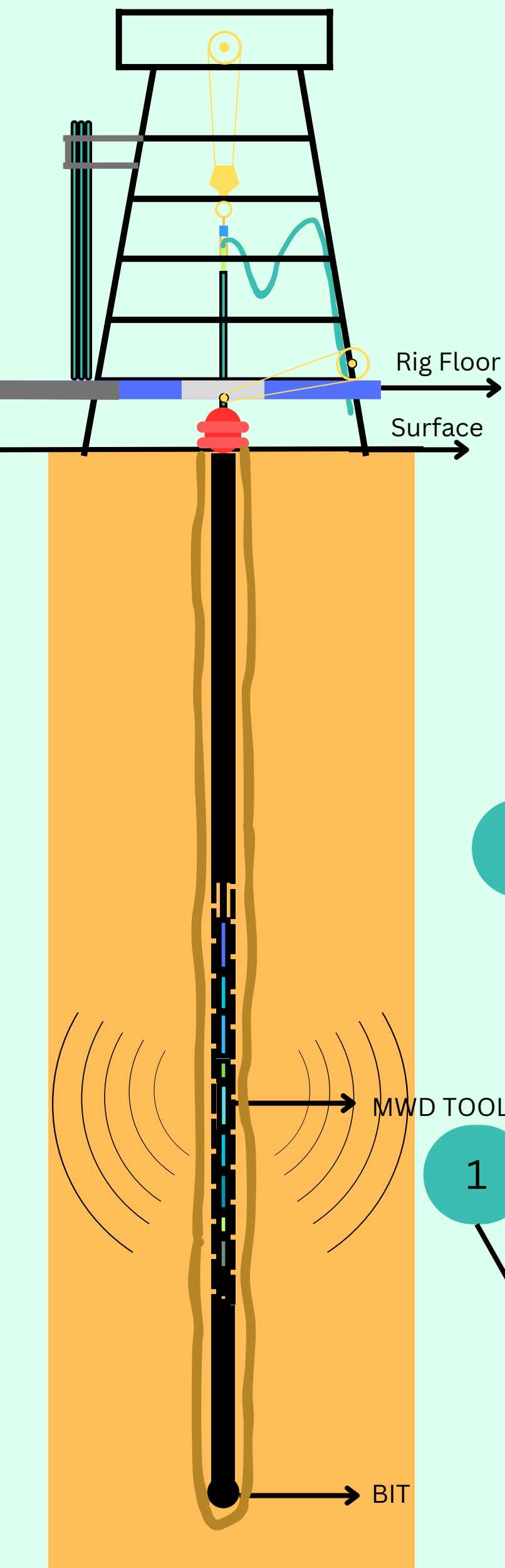
- 1. (UPS) Uninturupted Powe Supply
- 2. Barrel Wrench
- 3. Pressure Transducer
- 4. Rig Floor Display Unit
- 5. Pick-Up Plate
- 6. Digital Multimeter
- 7. Remote Terminal Case
- 8. Spanner Wrench
- 9. Small Dart Float, Large Flapper Float
- 10. Vibration Switch

- 1. Drill Pipe Screen
- 2. Muleshoe Crawn Wrench
- 3. Ring Bar
- 4. Orienting Bar
- 5. Short Sinker Bar
- 6. J - Wrench
- 7. Over shot Bell
- 8. Over Shot
- 9. Long Sinker Bar
- 10. Spang Jars



(MWD) Operation

The idea is to deliver the data from the downhole measurements and mud pulser (**Encoding**) to the surface (**Decoding**).



Decoding:

Downhole measurements and mud pulser.
At the surface, MWD surface systems decoding the data.

Transmitting:

Three main transmitter types are **electromagnetic wave, mud pulse and wired pipe**.

Mud pulse tools operate by either opening or closing a valve in the tool that creates either a pressure surge (positive pulse) or drop (negative pulse). Mud pulse systems are a reliable transmission method.

Electromagnetic telemetry: the tool sends either a magnetic pulse or electrical current through the ground to the surface. On surface the data is received through ground antennas and the data processed.

EM systems are significantly faster (10x) than conventional mud pulse. In addition data can be sent at any time (not just when the rig pumps are circulating)

Wired pipe: it is drill pipe which has wire to transmit data and the wire is directly connected to surface computer.

Encoding:

Downhole measurements and mud pulser.

Directional data:

- Azimuth (horizontal direction) and inclination (vertical angle) of the wellbore.

Drilling parameters:

- Weight on bit (WOB).
- Rotary speed.
- Torque.
- Mud flow rate.
- Temperature.

Formation evaluation:

- Properties of the rock formations:

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4- etc...

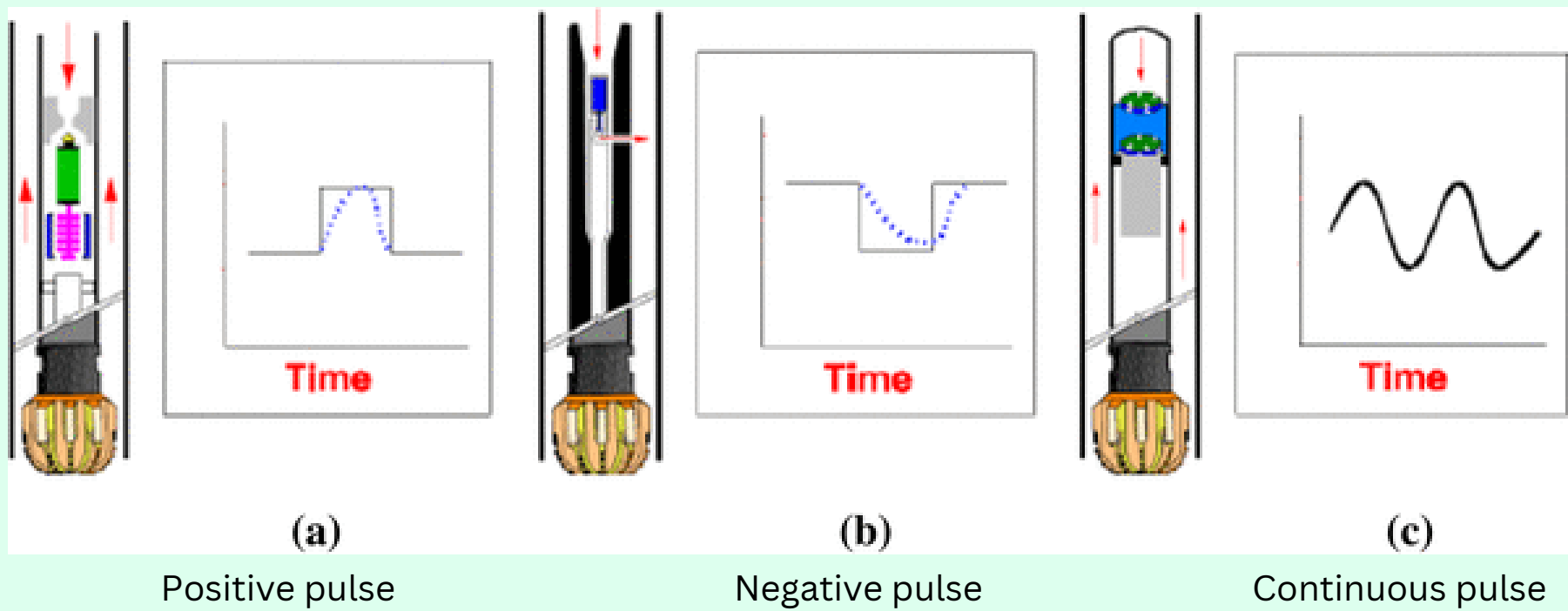
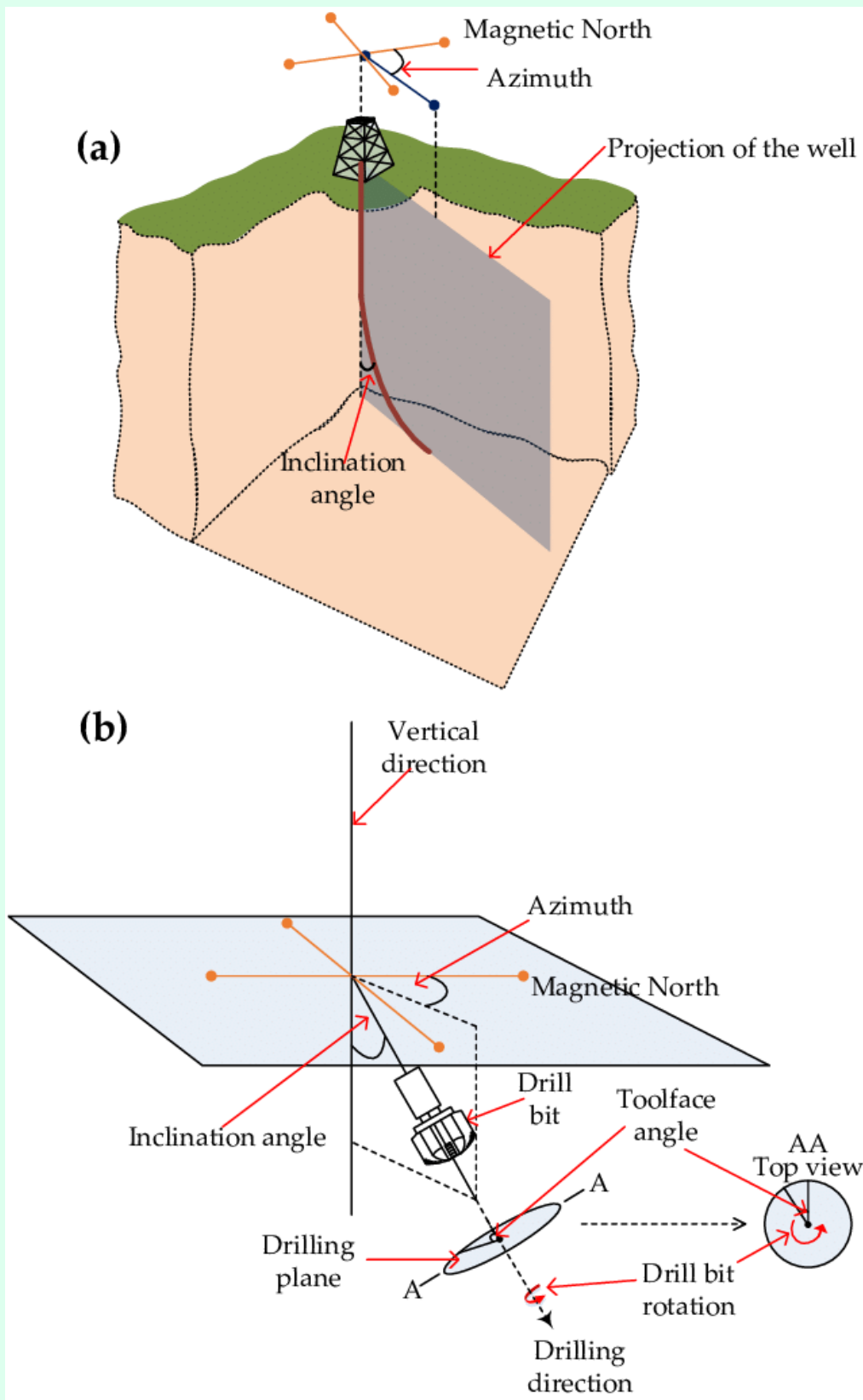
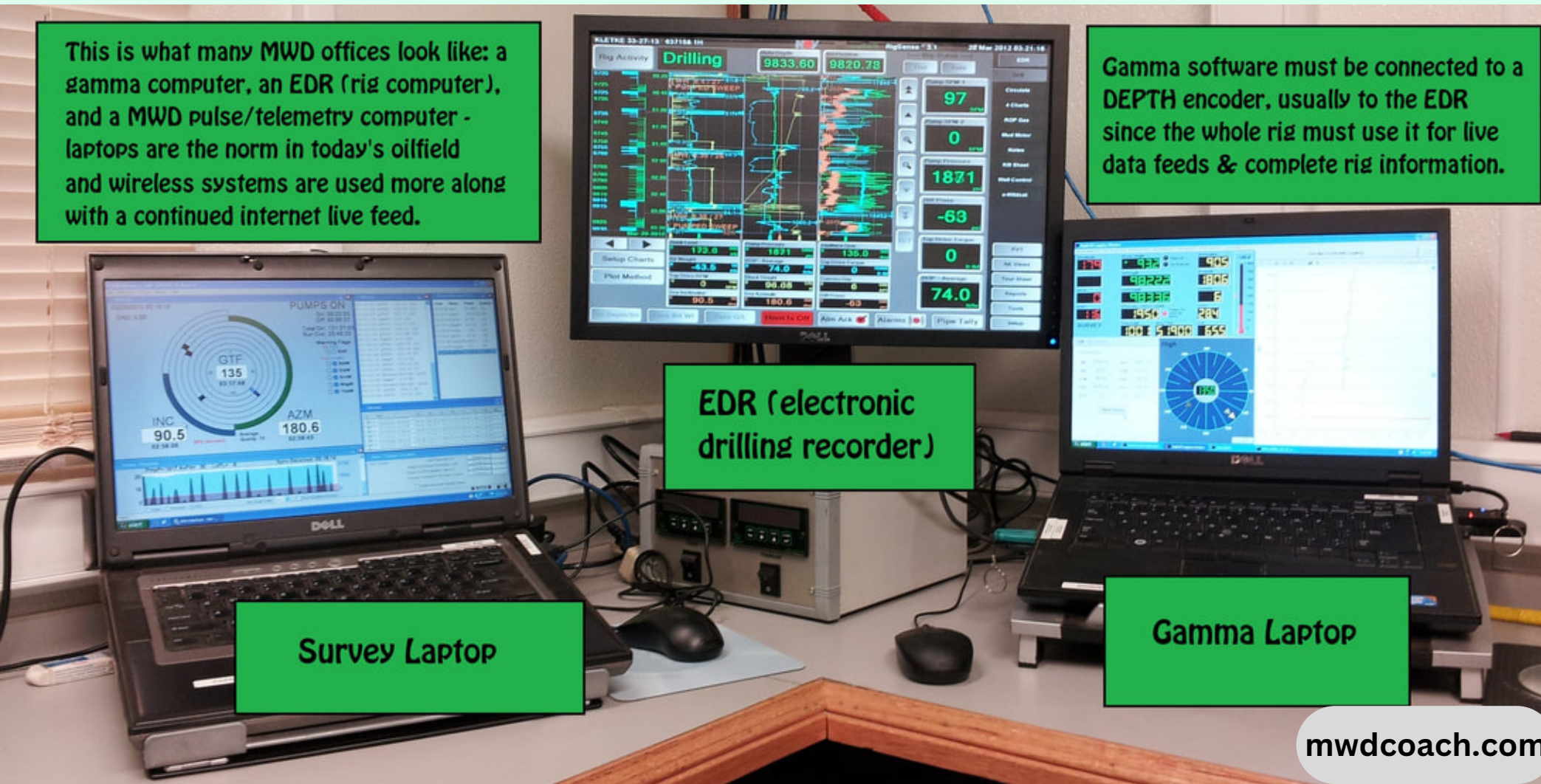
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(MWD) Data

At surface system, we can get:

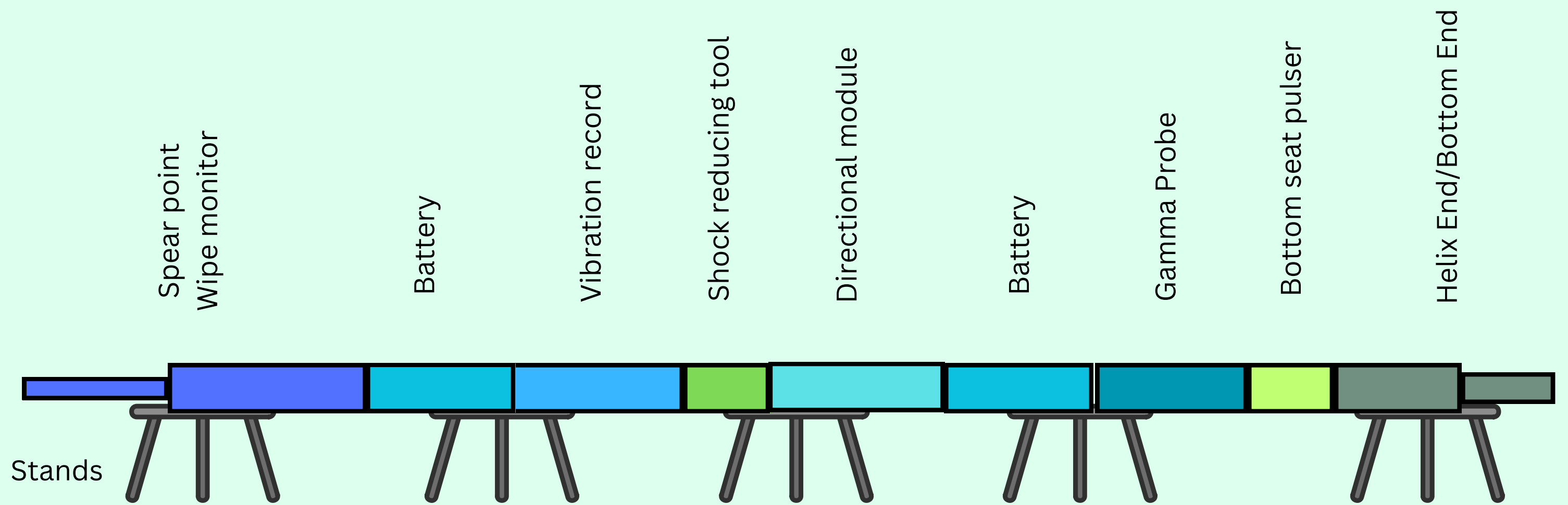
- Pulse Pressure.
- Azimuth (horizontal direction) and inclination (vertical angle) of the wellbore.
- Weight on bit (WOB).
- Depth.
- Rotary speed.
- Torque.
- Mud flow rate.
- Temperature.
- Properties of the rock formations.
- Shock and vibration data.
- Etc...



Initial depth:		0.00		Drill diameter:		12.00	
Time:		10:55 - 11:49		Depth [m]:		0.10 - 21,25	
Duration:		00:34:00		Length [m]:		21,15	
Depth [m]	Time	Rotation 170 [rpm]	Torque 100 [bar]	Force 90 [bar]	Speed 810 [m/h]	Energy 10 [KJ/m]	
0.10	10:55:44	110	48	33	452	4.4	
1.00	10:59:17	84	48	15	458	3.3	
1.90	11:00:19	90	60	48	558	3.6	
2.90	11:00:33	115	72	85	686	4.7	
3.80	11:02:07	148	40	15	527	4.3	
4.70	11:02:17	144	38	35	604	3.5	
5.70	11:02:24	132	42	37	585	3.8	
6.60	11:04:41	149	40	31	570	3.9	
7.60	11:04:49	138	44	33	604	3.8	
8.50	11:04:55	138	38	35	630	3.2	
9.40	11:06:12	154	40	28	558	4.2	
10.40	11:06:28	152	42	9	497	4.8	
11.30	11:06:45	152	42	5	514	4.7	
12.20	11:07:59	133	48	36	452	5.5	
13.20	11:08:29	90	42	7	720	2.0	
14.10	11:08:33	90	38	5	686	1.9	
15.10	11:08:39	91	43	4	585	2.5	
16.00	11:10:25	148	84	2	510	8.9	
16.90	11:11:06	91	48	5	458	3.6	
17.90	11:13:37	91	44	5	454	3.3	
18.80	11:27:30	155	66	30	686	5.8	
19.70	11:27:34	131	55	32	810	3.3	
20.70	11:29:10	121	71	36	457	7.1	
21.60	11:30:33	92	93	46	462	7.0	
21.25	11:49:01	158	76	12	455	9.9	



(MWD) tool, system check



System Check:

Every prob must be checked to prevent any failure.

Pulser test:

Badder, Tap, Light and Finger tests.

Roll Test.

Flow Test.

Tool memory.

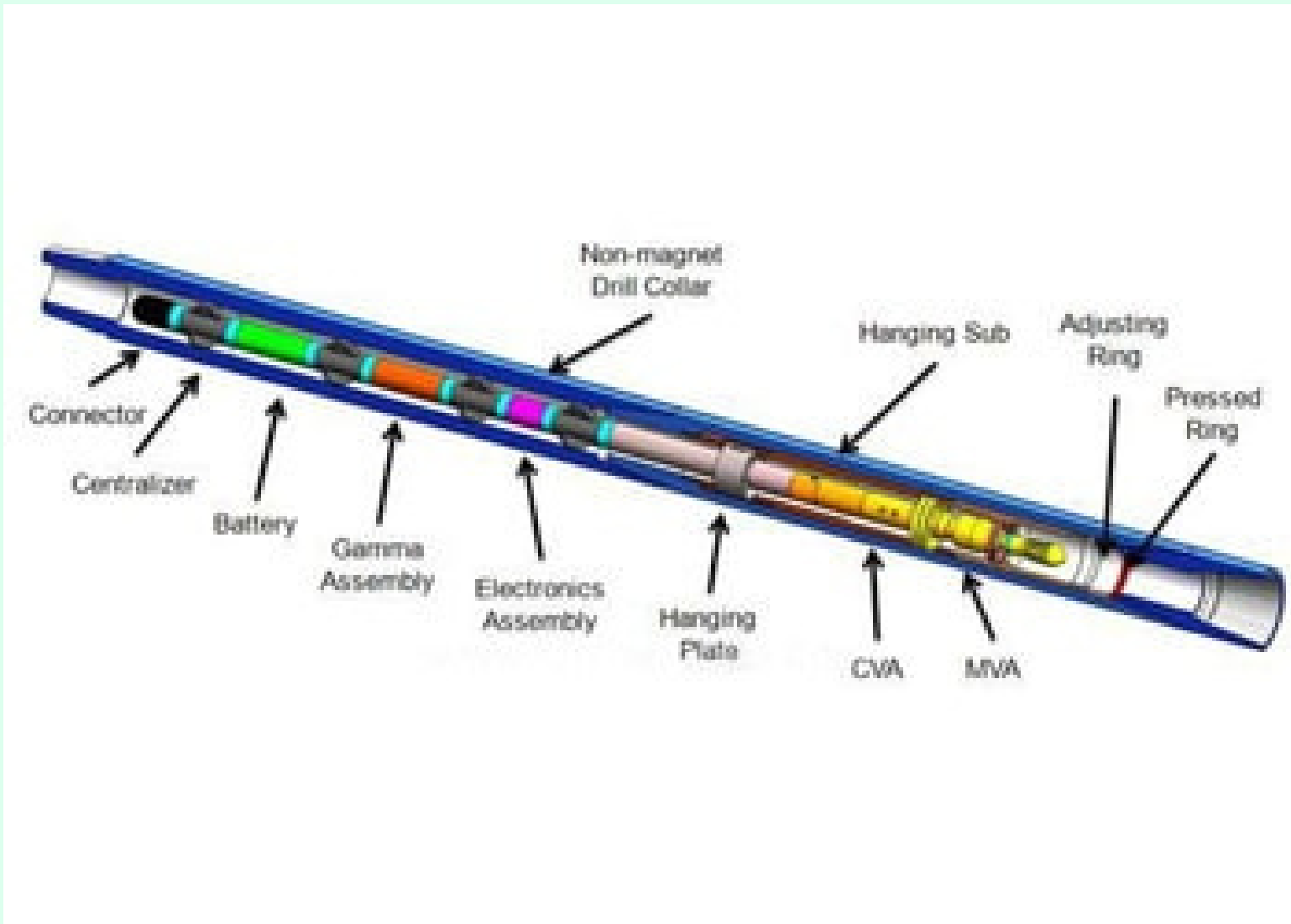
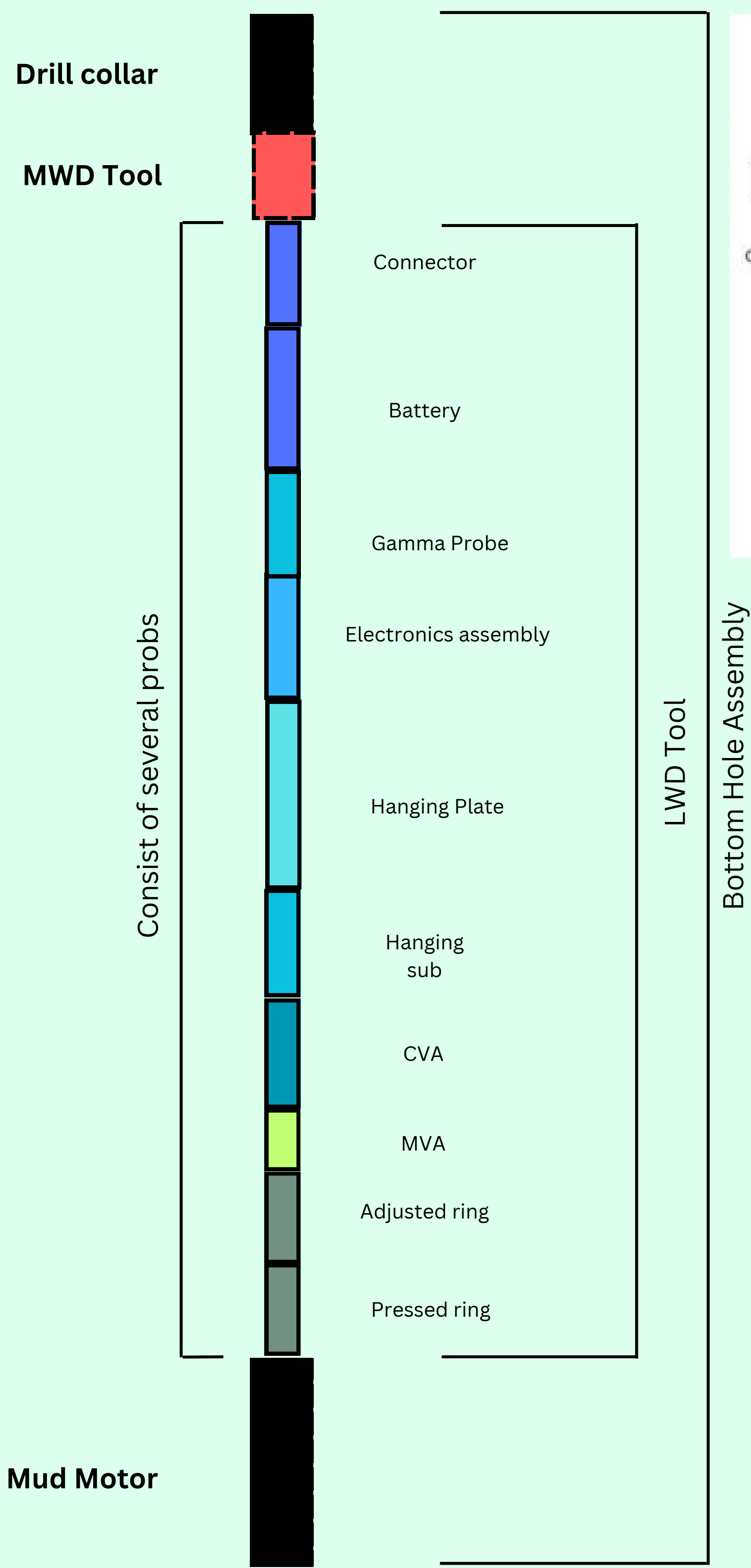
Programming and and surface system.

Etc...



(LWD) tool

Main Components: power, controller, sensors and transmitter



Notes:

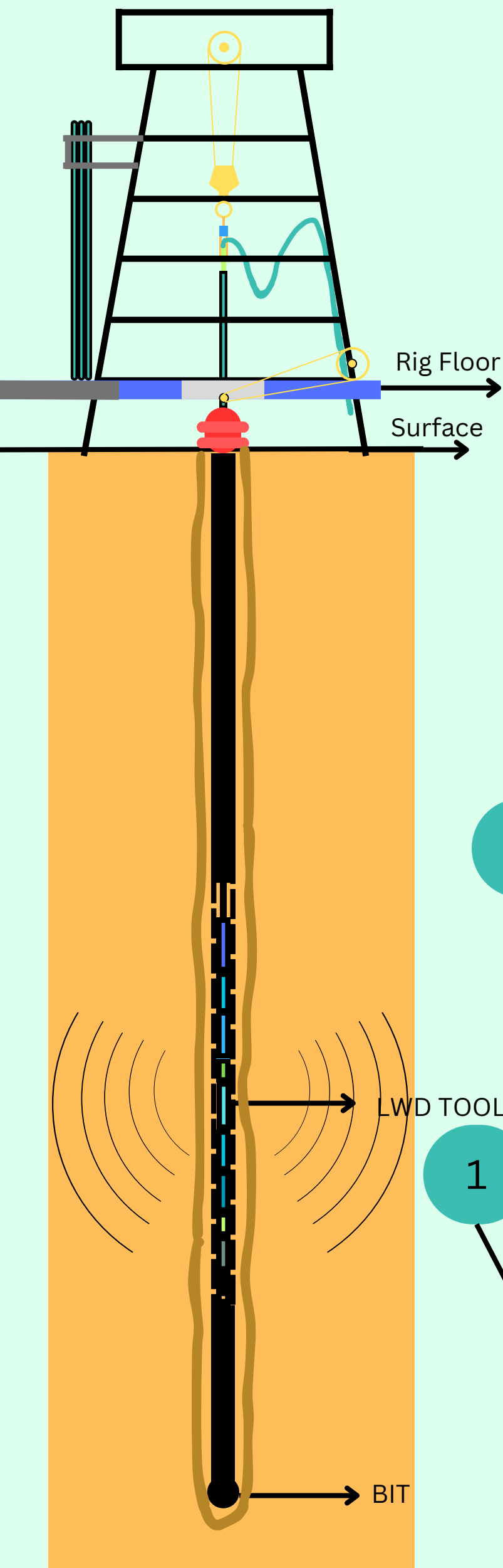
- The LWD probs can be changed, reorder, add, depends on type of the LWD Tool.

Information we can get from the LWD tool:

- Rock composition: information on strata types (limestone, shale, sandstone, etc.)
- Rock characteristics: porosity, permeability, presence of liquids.
- Rock integrity: presence of structural weaknesses, risk of caving.
- Borehole dimensional properties: size, shape, borehole trajectory.
- Liquid presence: properties of the fluids (if any) present in the borehole (e.g., salinity, pressure, saturation, etc.)

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(LWD) Data

At surface system, we can get:

• Natural gamma ray (GR):

- Total gamma ray
- Spectral gamma ray
- Azimuthal gamma ray
- Gamma ray close to drill bit.

• Density and photoelectric index.

• Neutron porosity.

• Borehole caliper

- Ultra sonic azimuthal caliper.
- Density caliper.

• Resistivity (ohm-m)

- Attenuation and phase-shift resistivities at different transmitter spacings and frequencies.
- Resistivity at the drill bit.
- Deep directional resistivities.

• Sonic

- Compressional slowness (Δt_c)
- Shear slowness (Δt_s)

• Borehole images

- Density borehole image
- Resistivity borehole image

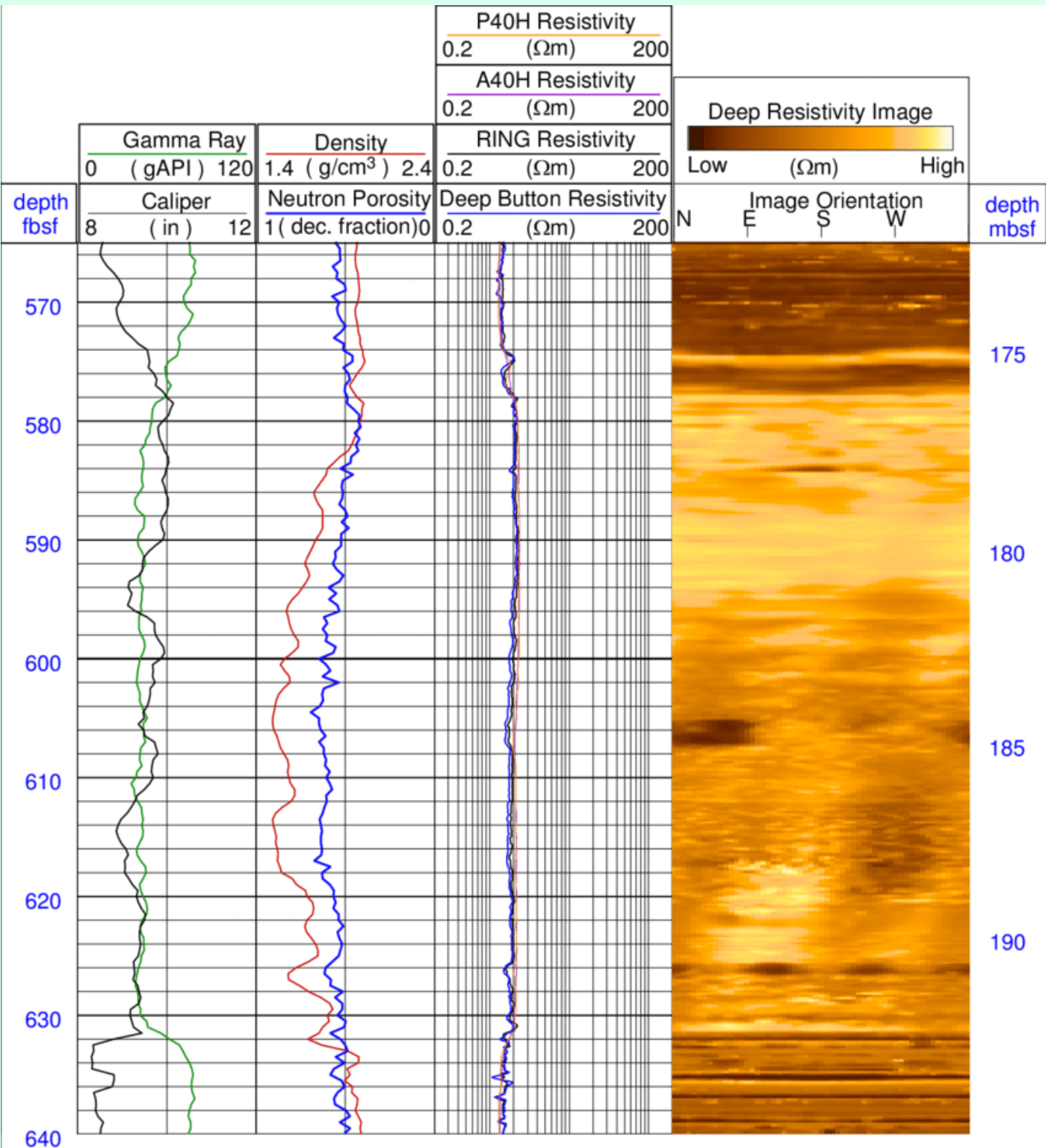
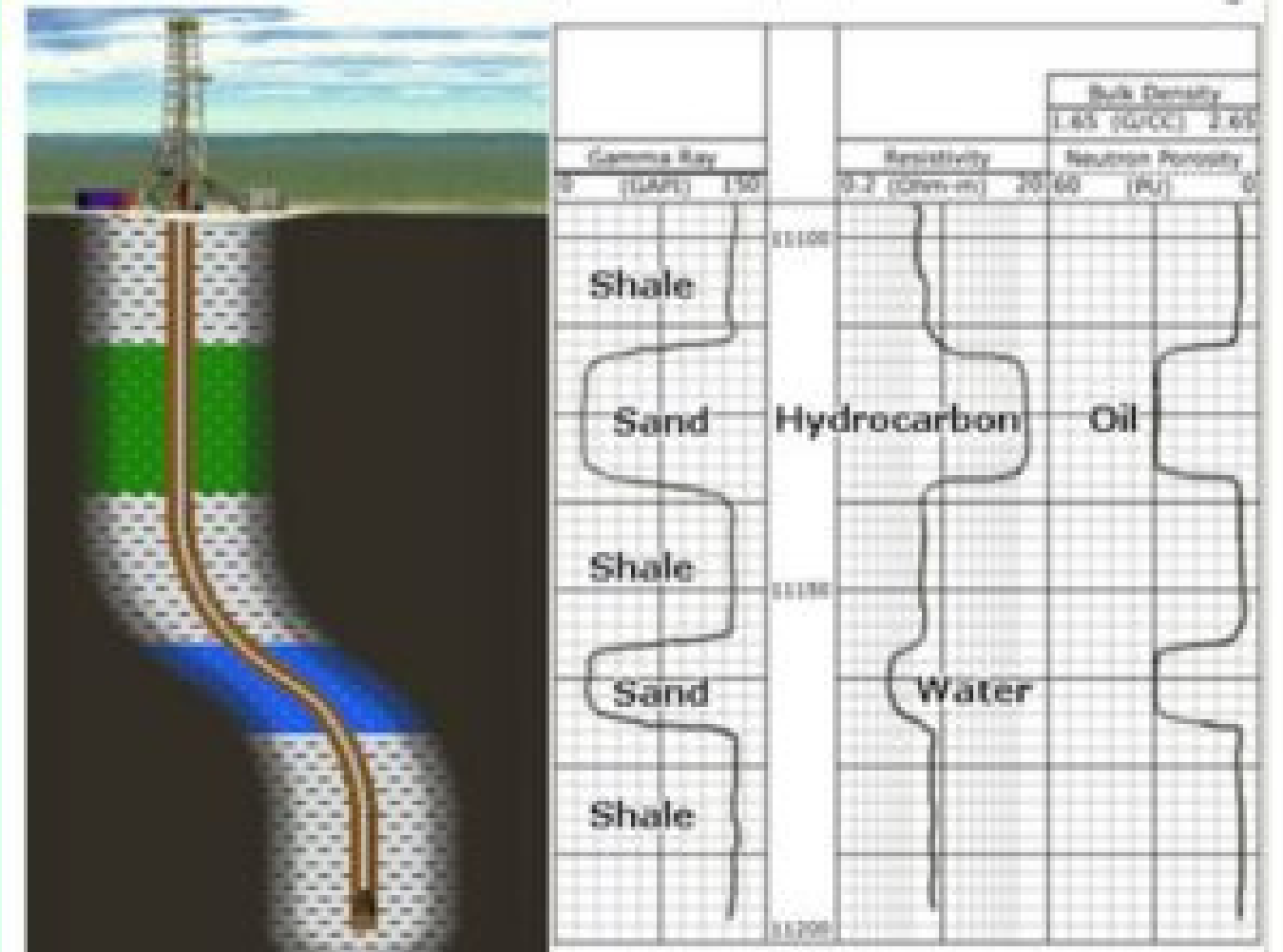
• Formation tester and sampler

- Formation pressure
- Formation fluid sample

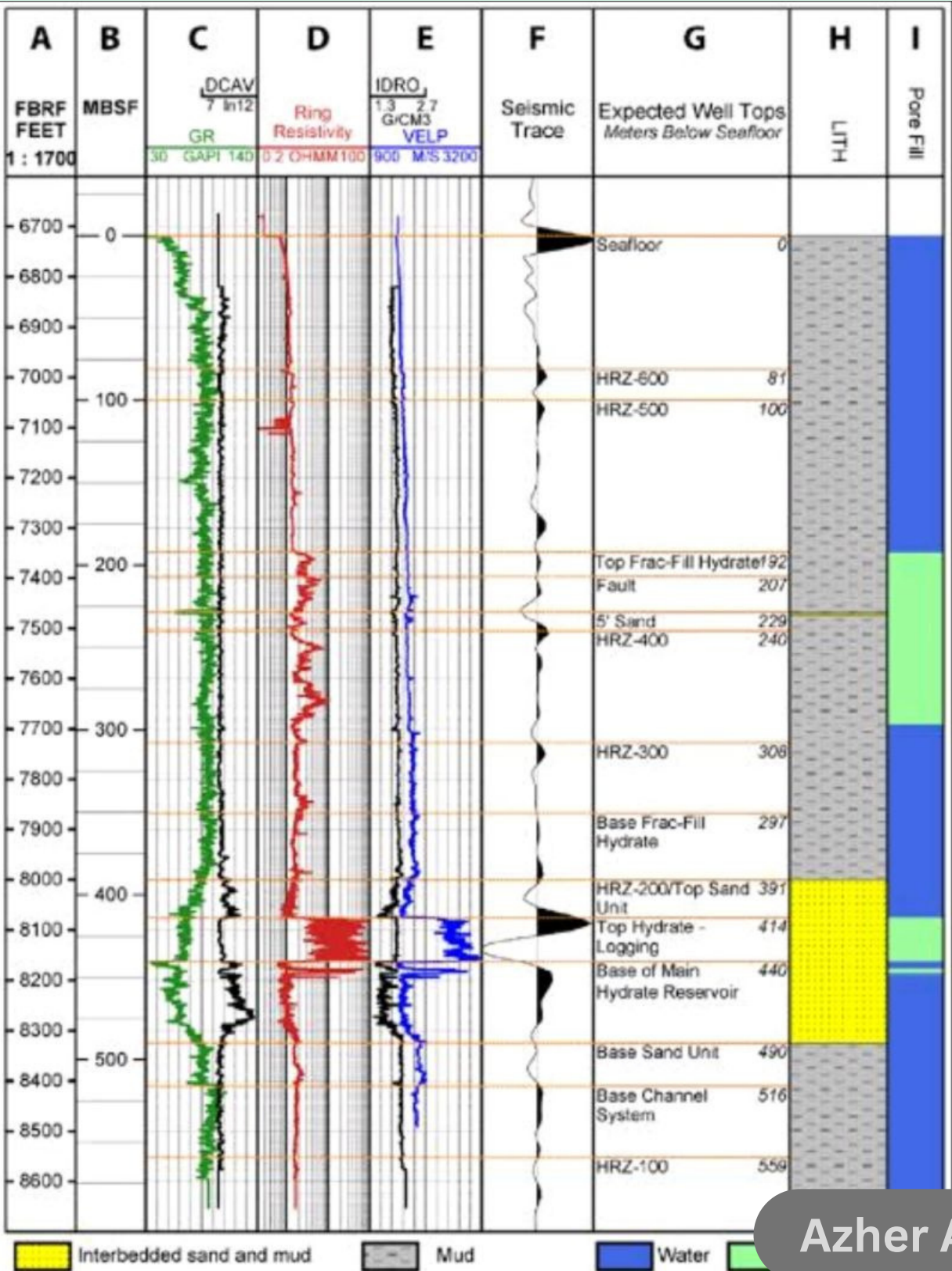
• Nuclear magnetic resonance (NMR)

• Seismic while drilling (SWD)

- Drillbit-SWD



Lithology		GR	Density	Neutron	Acoustic	Resistivity
Sandstone		Low (Unless RA min)	2.65	-4	55	High
Limstone		Low	2.71	0	47.5	High
Shale		High	2.2-2.7 (water content)	High (water content)	50-150 (water content)	Low (water content)
Dolomite		Low Higher if U	2.85	+4	42.5	High
Anhydrite		V.Low	2.95	-1	50	V.High
Salt		Low (Unless K salt)	2.1	0	67	V.High
Water		0	1-1.1 (salt & temp)	100	180-190	0-infinite salt & temp
Oil		0	0.6-1.0 (API)	70-100 H2 index	210-240 (API)	V.High
Gas		0	0.2-0.5 (pressure)	10-50 H2 index	1000	V.High



MWD

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Drilling parameters:

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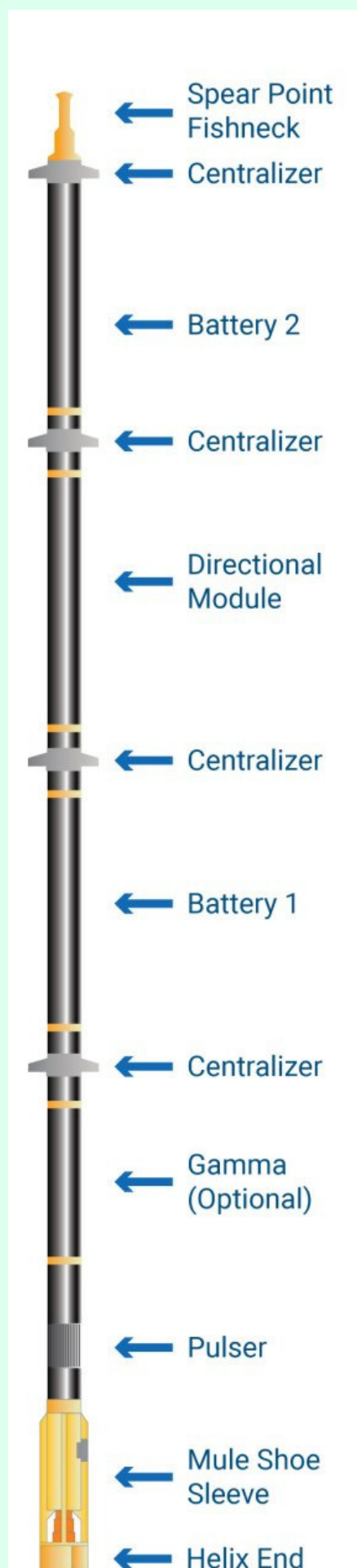
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