

# Triple Combo Tool String

## Scientific Application

The Triple Combo tool string is always run first and acquires most of the basic petrophysical and lithological logs (density, porosity, resistivity, gamma ray). This string also measures the borehole width, an important indicator of borehole and log quality.

The porosity, density, and resistivity logs collect petrophysical and geotechnical information about the penetrated formations. In sediments, the general trend in these logs is dominated by increasing consolidation with depth. Deviations from this trend are caused by lithological change, lithification (cementation), underconsolidation (e.g., high pore-fluid pressure), or the presence of gas hydrates (hydrate in the pore space increases resistivity and sonic velocity). The principal advantage of these logs over the equivalent core measurements is that the logs record the in-situ property, whereas the cores are expanded and depressurized and can suffer from end-effects and biscuiting.

## Components

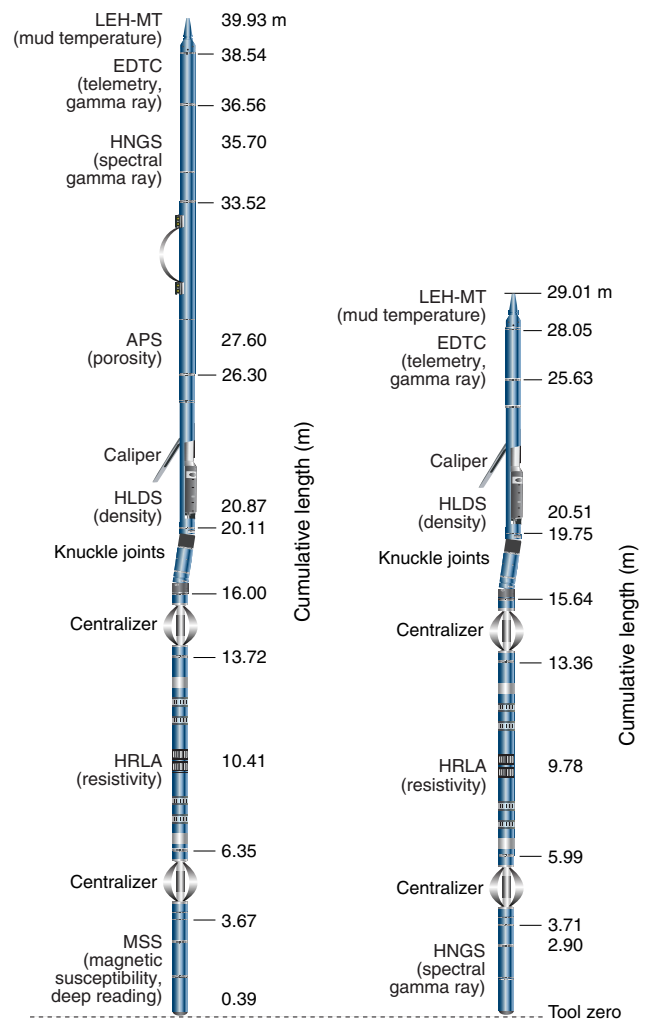
The standard Triple Combo logging tool may consist of three of the following tools:

- Accelerator Porosity Sonde (APS\*)
- Hostile Environment Litho-Density Sonde (HLDS\*)
- Hostile Environment Natural Gamma Ray Sonde (HNGS\*)/Enhanced Digital Telemetry Cartridge (EDTC-B\*)
- High-Resolution Laterolog Array (HRLA\*)/Phasor Dual Induction-Spherically Focused Resistivity Tool (DIT\*)
- Magnetic Susceptibility Sonde (MSS-B) (developed by Lamont)

## Deployment Notes

### APS

An electronic neutron source (mintron) and five detectors provide information for porosity, gas detection, clay evaluation, improved vertical resolution, and borehole corrections. The APS is typically run with the DIT, HLDS, and HNGS tools. Tool length is 3.96 m (13 ft).



**Examples of two different Triple Combo tool string configurations (Exp 349).**

## HLDS

The HLDS consists of a  $^{137}\text{Cs}$  source and two detectors mounted on a shielded skid that is pressed against the formation. Bulk density and photoelectric formation factor are derived from the spectra measured by the detectors. The available spectral information from the HLDS is also used for improved log and calibration quality control. The HLDS is typically run with the HNGS and APS tools. It can be combined with DIT, DLL, and ASI. Tool length is 3.83 m (12.58 ft).

## HNGS

The HNGS utilizes two bismuth germanate (BGO) scintillation detectors to measure the natural gamma ray radiation of the formation. At least one pass is made with the HNGS past the mudline for correct location of the mudline itself. Depending on the environment, the HNGS may be run on other tool strings as well. Tool length is 25.88 cm (8.5 ft). The gamma ray log is generally used to depth match between logging runs.

## EDTC-B

EDTC-B is a downhole tool that combines two commonly run sensors with a high-speed telemetry downhole modem that can be used in high-pressure and high-temperature environments. The primary function is to provide high-speed (>1 Mbps) communications between the wireline tools downhole and the acquisition system at surface. Additionally, it includes a scintillation gamma ray detector that provides a measurement equivalent to that of the Scintillation Gamma Ray tool formerly used for seismic operations. The gamma ray log is generally used to depth match between logging runs.

## HRLA

The HRLA tool provides six resistivity measurements with different depths of investigation (including the borehole, or mud resistivity, and five measurements of formation resistivity with increasing penetration into the formation). The HRLA is typically deployed on the Triple Combo tool string in high-resistivity environments. It is compatible with virtually all other tools commonly used on the *JOIDES Resolution* except the Formation MicroScanner (FMS), and unlike the bottom-only DIT, it can be run higher in the string should it be necessary to combine it with a bottom-only tool such as the MSS. Tool length is 7.35 m (24.1 ft).

## DIT

The DIT provides measurements of spontaneous potential (SP) and three different resistivity values: IDPH (deep induction), IMPH (medium induction), and SFLU (shallow spherically focused resistivity). Since the solid constituents are orders of magnitude more resistive than pore fluids in most rocks, resistivity is controlled mainly by the conductivity of the pore fluids and by the amount and connectivity of the pore space. Typically the DIT is run with APS, HLDS, and HNGS. The DIT has an internal temperature measurement that may be useful in high-temperature environments.

## MSS-B

MSS-B is a wireline logging tool that measures borehole magnetic susceptibility at two vertical resolutions and depths of investigation. When run in a Schlumberger tool string, the MSS-B must be run as the bottom tool below a pressure bulkhead. Most combinations of inline Schlumberger tools can be run above. Tool length (effective makeup) is 540 cm (212.6 in.).