



PDHonline Course K132 (3 PDH)

Basic Well Log Interpretation

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Joshua Cook, P.E.

COURSE CONTENT

1. Introduction

This course is intended for people who are interested in learning more about well logs. Anyone taking this course should be somewhat familiar with oil or gas well design and terminology.

A well log is a record of the well depth verses some physical parameter of the well. With it, estimations can be made of parameters such as formation type, thickness and depth, porosity, water saturation, and lithology.

There are many different types of logs that can be run on wells. They can be run in open hole or in cased hole. Generally, they are on wireline, slick line, or in a drill string.

The course will look a full well log and explain it piece by piece. The logs in this course are taken from the WV Geologic and Economic survey's website, which has many logs available to the public. There are similar organizations in other states that are also good sources for data.

In order to read a log effectively, you will need to understand what each parameter is. The parameters are not always accurate and can lead you wrong even if you are very careful. Well logging is certainly not an exact science so experience and study will be helpful. The best way to become good at reading logs is to practice. This course should get you off to a good start.

This course is consolidating information that is commonly taught over a semester in collage into a short course. There is considerable science beyond what is covered.

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2. General Information on Well Logs

A helpful resource in analyzing well logs are log interpretation charts. A number of service companies produce these books. Schlumberger produces a book called “Log Interpretation Charts”. This book will help you better estimate data from the well log. A number of corrections and more data can be gathered from using the chart. These charts will not be covered in this course, but they will be mentioned a few times.

3. Log Cover Page and Headers

COMPANY		PETROEDGE RESOURCES L.L.C.	
WELL		IRELAND # PH 4	
FIELD		MURPHY DISTRICT	
PROVINCE/COUNTY		RITCHIE	
COUNTRY/STATE		U.S.A. / WEST VIRGINIA	
LOCATION		SMITHVILLE 7.5' QUADRANGLE	
		WATERSHED :ROAD FORK	
		COMPACT	
		FINAL PRINT	
LSD	SEC	TWP	RGE
Other Services			
		Gamma Ray	
		Data Pack	
API Number		Sonic Gas Detector	
Permit Number 47-085-9450		Bht	
Permanent Datum Ground Level		Elevation 822 feet	
Log Measured From GROUND LEVEL		above Permanent Datum	
Drilling Measured From KB 7 Ft			
		Elevations	
		KB 829.00	
		DF 829.00	
		GL 822.00	
Date	05-MAR-2007		
Run Number	1		
Depth Driller	5900.00	feet	
Depth Logger	5993.00	feet	
First Reading	5993.00	feet	
Last Reading	1858.00	feet	
Casing Driller	1861.00	feet	
Casing Logger	1858.00	feet	
Bit Size	6.38	inches	
Hole Fluid Type	DUSTED		
Density / Viscosity			
PH / Fluid Loss			
Sample Source			
Rm @ Measured Temp			
Rmf @ Measured Temp			
Rmc @ Measured Temp			
Source Rmf / Rmc			
Rm @ BHT			
Time Since Circulation	6 Hours		
Max Recorded Temp	128.00	deg F	
Equipment Name	Compact		
Equipment / Base	13036	Weston	
Recorded By	Frank Lattea		
Witnessed By	Jerry Clark		
Field Ticket	40052	Last Line	

Figure 1

Figure 1 is an example of the cover page to a well log. While there may be some variation between logging companies, the basic information should always be there. Most of the information on this is self explanatory.

This page is often followed by another page of remarks or other notes.

The headers are next. These will give the scale and pattern for each of the lines on the log.

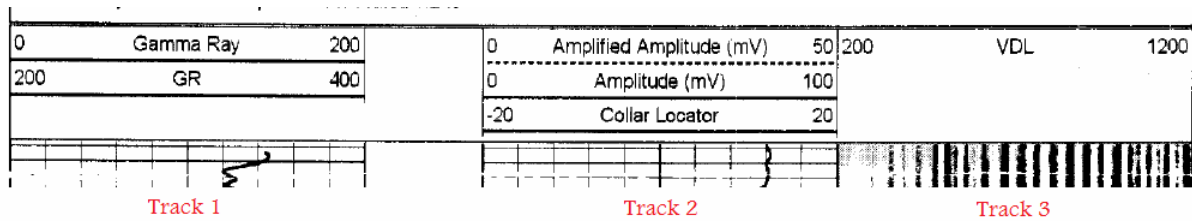


Figure 2

Logs are broken into 3 columns which are called tracks. Track 1 (Gamma Ray in Figure 2) is on the left. There is a space for depth and or other notes. Track 2 (Amplified Amplitude) is next it follows the space that displays the depth. Track 3 (VDL) is on the right. Track 2 and 3 are often used together allowing a parameter to span both tracks. A better understanding of this will be developed as we proceed.

4. Example Log

The first time you look at a log it may be a little overwhelming and figure out what all of the squiggly lines mean. Our example log (Figure 3) is no exception. The log starts at 1,850' in the Big Lime and Big Injun formations. In case you could not tell, this appears to have potential to be a productive zone.

We will go through each of the components of the log and explain what each one mean.

New well logs are nice and neat and easy to read. The older ones are not as pretty. The example presented is just nice enough to be able to read for this course. It is typical of logs that have been scanned into a public source. When practice studying well logs, you should take some time to look at older hard to read logs and get use to them. After that, the new ones will be easy.

The example was drilled with air, which does have some differences with wells drilled on mud. Certain logs can be run on air that cannot be run with mud and vice versa. An example of this would be running a video camera. It can work well with a gas filled hole, and not so well when the hole is full of mud. Logs on mud filled wells account for roughly 70% of logs.

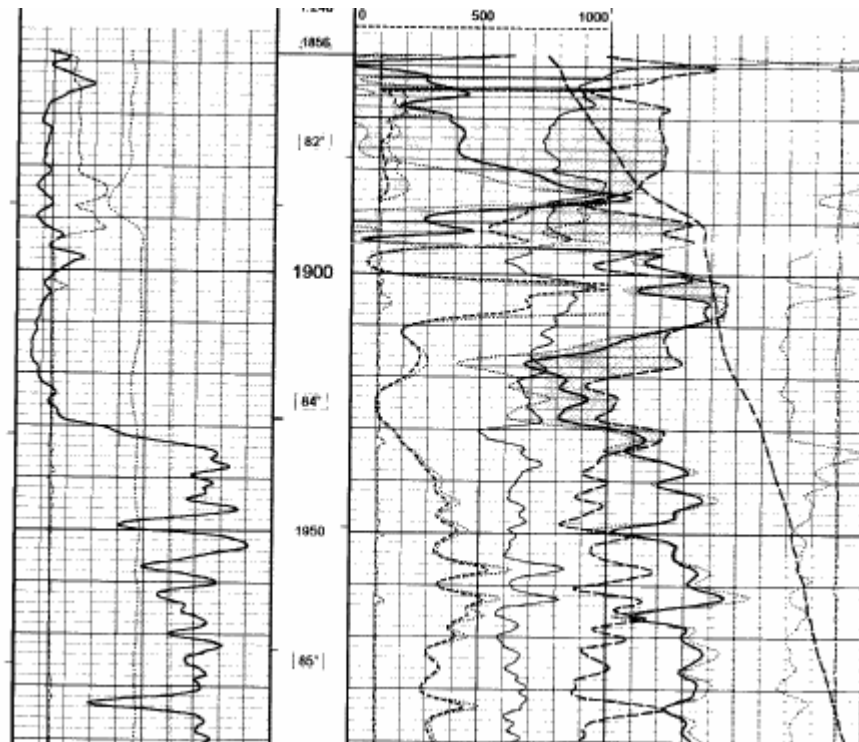


Figure 3

5. Logging Trucks/Surface Operations

The typical logging trucks look similar to a trash truck. A truck has a room built behind the cab. In the back of the truck is a large spool of wireline. This wireline contains insulated wires that transmit data from the downhole tools to the computers.

The downhole logging tools are packed away in compartments in the truck. They all look a little different. They usually connect by threading into each other. Each downhole tool is about 10'-15'. Depending on what logs are being run, the length of the tools put together can be from 30' to 90'+.

The logging truck will arrive at the rig and park with the back end at the end of the pipe racks. They will rig up the wireline on pulleys which are attached to the rig floor and traveling blocks. To pick up the tools, the wireline from the logging truck is attached to each tool. The tools are carefully raised to the rig floor and attached to the previous tool and lowered in the hole. The tools will then be lowered to bottom of the well (TD).

Logs are run from TD up. When wire is in tension it will stretch. This stretch can be calculated if the tension is known. While the tools are being pulled out of the well, it is easier to estimate all of the forces on the wireline. This gives more accurate calculation of depth.

6. Wellbore Profile

The Figure 4 shows a representation of a well and a surrounding zone. When mud is in a well, some water will be lost into the formation. This is caused by the pressure of the mud being higher than the pressure of the formation. Essentially, the formation will filter the water out of the mud. The water that goes into the formation is called filtrate. The mud that is left on the sidewall of the wellbore is called mudcake. The filtrate will push all of the gas, oil, and/or water away from the wellbore. The zone is called the flushed zone. Where part of the water has been pushed away is called the transition zone. The area that has not had any contact with filtrate is the uninvaded zone.

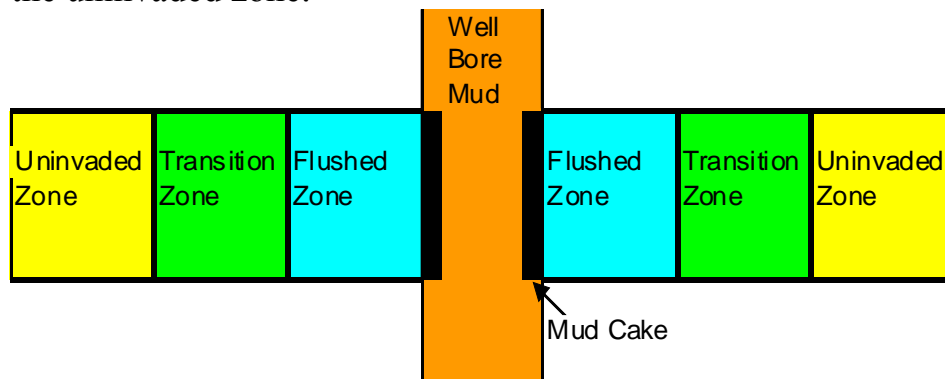


Figure 4

It is important to understand what each zone is and how that will affect the logs. A good chart book will be helpful in many cases to correct for the filtrate. A thorough understanding of all the affects of filtrate invasion goes mostly beyond this course, but a general understanding of this concept will be helpful. Our example well was drilled with air/foam, so the flushed and transition zones are negligible. This is because with air/foam the formation pressure is higher than hydrostatic pressure.

7. Open Hole Logging

Open hole log are logs that are run in the well after it has been drilled and before casing has been run on the section of the hole that is being logged. This course will cover some of the basic types, what they do, and how to read them.

A. Gamma Ray

The Gamma Ray is the most important function to understand. It is the measurement of the natural gamma rays produced by the formation. These gamma rays come from the decay of radioactive isotopes like potassium, thorium,

and uranium. Generally speaking, shales will produce more gamma rays than limestones and sandstones. It is this quality that allows us to tell the difference between shales and other types of rock.

The Gamma Ray tool can be used in both open hole and cased hole logging operations. For this reason, it is often used to correlate one log to the next. This will be discussed more in detail later in section on log correlation.

The Gamma Ray is presented on track 1. It is measured in API units. 0 is on the left and the scale goes up as it goes to the right. In some instances, the log will reset. In our example, you see the scale goes from 0 to 200 and 200 to 400. In the example below you can see this.

In Figure 5, the Gamma Ray is the dark solid line. At 5905' the Gamma Ray goes over 200 and the line jumps back to the left side of the graph as the value increases to 280.

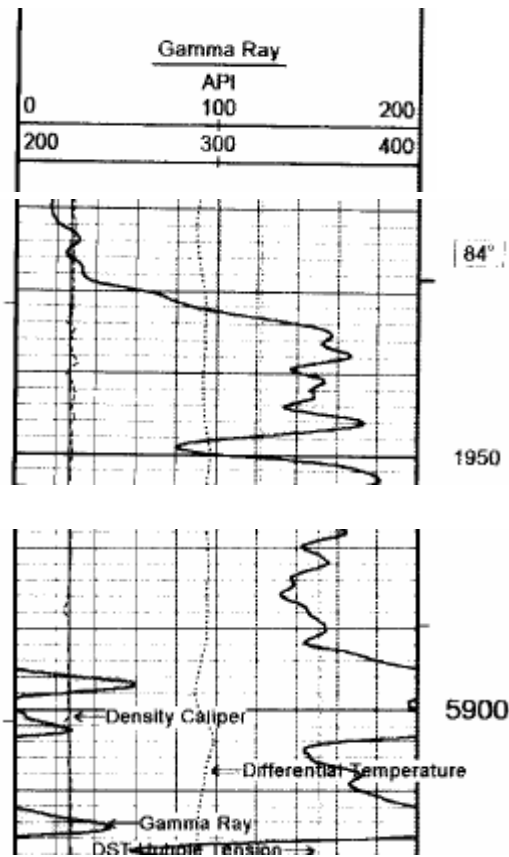


Figure 5

The in the example, the zone above 1930' is not shale. Around 1935' the formation is mostly shale. The high gamma ray zone around 5900' would sometimes be referred to as a "hot shale". This is in reference to the high gamma ray count that is in this shale. Usually, they are organic rich shales.

It is possible that formations that are not shale have high gamma rays, making them look like shales. Although this is rare, it does happen and a local knowledge is useful.

Shales have high gamma ray values, other rock such as limestone, sandstone, and evaporates usually have low gamma ray values. Formations will vary from having no shale to being all shale. This will give values that span the range. Generally, a formation will have similar values from one area to the next. This makes it possible to correlate zones from one well to the next.

B. Spontaneous Potential

The spontaneous potential is the measurement of electrical current created in the well. These currents are created by the interaction between the fresh water filtrate from the mud and the salt water in the formation.

It can only be run if the hole is loaded with a fresh water mud and it will need to be run with resistivity tools.

The tool can be used to locate formation depths, detect permeable formations, determine formation water resistivity, and to indicate bed shaliness.

It is typically presented in track 1 of the log. Typically, the log will look very similar to the Gamma Ray. In fact, the gamma ray log was developed to replace the Spontaneous Potential log.

C. Porosity

Porosity is the amount of space in the rock that is not solid. This space will be filled with a gas or liquid.

Density – The density tool measures the bulk electron density of the formation and that is used to calculate the porosity.

The simplified explanation of the tool is as follows. The tool has a chemical source that emits gamma rays. As the gamma rays travel through the formation, the rays interact with the atoms of the formation. Some of the gamma rays will return. The more gamma rays that return, the more porous the formation. From this, the density is determined.

On older logs you may just see the bulk density of the formation, in g/cc.

The density is used to calculate the porosity with the following equation.

$$\phi = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} \quad \text{where} \quad \begin{array}{l} \rho_{ma} = \text{density_of_matrix} \\ \rho_b = \text{density_from_log} \\ \rho_f = \text{density_of_fluid} \end{array}$$

Newer logs will be set up to calculate the porosity. Our example log uses 2.71g/cc for the density and 1.0g/cc for the fluid. These are the values for limestone and fresh water respectively. Logs are often run using the limestone values, though they can be run using 2.65g/cc for sandstone or something else if desired. It is important to understand this as when sandstone is encountered. The real porosity will be lower than the limestone porosity. Sandstone has a density of about 2.65g/cc. This is a lower density than the limestone. Sometimes, the density used will be changed in middle of the log. You can also check to be certain the calculation is right by calculating the porosity from the bulk density, but it also should be noted in the remarks section and on the log where it changes.

Sonic – The sonic or acoustic tool uses the travel time of a compressional wave through the formation to estimate porosity. The older tools have 2 receivers, one about 1 foot below the transmitter and the other 2 feet below that. It operates by transmitting a wave. The receivers detect the wave. The time difference between the two is the travel time of the wave (ΔT_{\log}). Newer sonic tools have more features but basically operate using the same theory.

The following equation is used to calculate the porosity.

$$\phi_s = \frac{\Delta T_{\log} - \Delta T_{ma}}{\Delta T_{ma} - \Delta T_f} \quad \text{Where} \quad \phi_s = \text{Porosity} \quad \Delta T_{ma} = \text{Matrix_travel_time}$$
$$\Delta T_{Log} = \text{Interval_travel_time} \quad \Delta T_f = \text{Fluid_travel_time}$$

The matrix travel time is the speed sound waves travel through the rock. It is the time that it would take for the wave to travel through the formation if there was 0% porosity.

The fluid travel time is the speed that the waves travel through the formation fluids.

The log will be run using a particular matrix, usually limestone. Corrections can be made if you are studying a different type of formation, such as sandstone.

Any type of fractures or vugs will give false readings.

The sonic porosity will give high values for oil filled zones and higher values for gas filled zones. This is due to sound traveling faster through rock than through oil and more so through gas.

The sonic porosity being higher than the density porosity indicates a gas zone.

Neutron – The Neutron tool are also used to estimate the porosity. The tool operates by emitting neutrons into the formation. When the neutron collides with

an atom of similar size such as a hydrogen atom, the atom absorbs the neutron and emits a gamma ray. The tool measures this.

The Neutrons that are emitted are from a chemical source, usually PuBe or AmBe. Like the source for the density tool, these are radioactive sources and require caution when using.

Hydrogen atoms are in natural gas, oil, and water. These generally represent the porous portion of the rock. The in gas filled pores the neutron tool will read lower porosity due to the hydrogen atoms in the gas being far apart. Whereas the oil and water filled portions are approximately the same.

When the neutron porosity drops below the density porosity, this usually indicates gas. If you refer back to Figure 3, you will see our sample log makes the area where the neutron density is less than the density porosity grey. While this is not always a foolproof method, it usually works well.

The older neutron logs are presented on a count rates instead of as a porosity percentage. The newer logs are presented on a porosity percentage scale. This is typically based on a limestone matrix. Again, if you are studying a formation that is not limestone, corrections may need to be made.

The log interpretation charts will help correct for a more accurate porosity.

D. Induction/Resistivity

The resistivity tool is used to determine the electrical resistance of the formation. From the resistivity, the water saturation can be estimated.

Most formation waters have high salt concentrations. Electric passes easily through salt water. Electric does not pass through hydrocarbons easily.

Resistivity tools can only be used in water based muds that have at least a low level of salt concentration. Induction tools can be used in other instances.

The resistivity tool operates by creating an electrical current in the well. The current will travel through the formation and back to the tool. Thus resistance to the current is measured.

The induction tool operates by creating a magnetic field with a transmitter coil. There is a receiver coil that measures the magnetic field. The formation resistance changes, this will cause a change in the magnetic field. Thus the magnetic field is used to determine the resistance of the formation.

Water saturation can be determined from the resistivity and induction tools.

Numerical values for formation water saturation can be determined using a chart from the service company.

The basic understanding should be this: Low values for induction or resistivity indicate the formation contains mostly salt water. High values indicate the formation contains oil, gas or very fresh water.

The tool can be used to determine if there is permeability. If the well is drilled overbalanced (hydrostatic pressure in the well is more than formation pressure) the mud filtrate will invade the formation. Assuming the filtrate has a different conductivity than the formation, we can see the effects on the resistivity log. The log will take measurement at two (or more) different distances from the wellbore. The mud filtrate should not affect the deep measurement as much as it will affect the shallow measurement.

In other words, if the deep measurement is higher than the shallow measurement, the formation is permeable (assuming the filtrate is more conductive than the formation). This is because the filtrate moved the formation fluid out from near the well, but it has not moved to the deep measurement's focus.

E. Temperature

The temperature log is a record of the temperature of the well. In liquid filled holes it is important to know the temperature for correlations and corrections. The temperature log is much more of a valuable tool in air filled holes. There are zones that have been completed based solely on a temperature fluctuation. In Figure 6 we can see an example of how temperature can change when fluids are entering the well. Follow just the temperature line. It moves diagonally from the left to the right as it goes down deeper. In the sand at 2304', you see it diverts from its nearly straight line and goes to the left. Once it is past the zone at 2310' it continues on its path. In this case, there is fluid entering the well making it warmer.

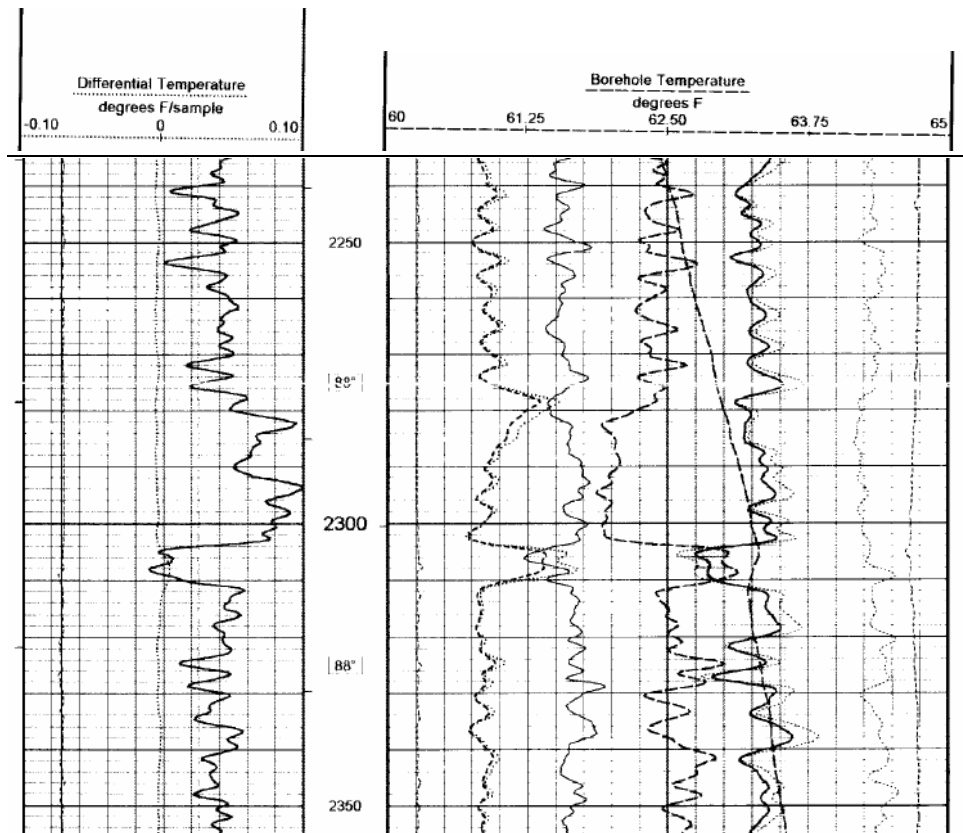


Figure 6

Our example is typical. The temperature in the wellbore will increase as it gets deeper. Typically the formation temperature will increase 1 to 1.5 degrees per hundred feet. This can vary considerably based on geology, but is a good rule of thumb.

When fluids enter the well, a few things can happen. If the well has been cooled off by the drilling fluid and the temperature of the formation is warmer than the wellbore, fluids can cause an increase in temperature. If there is gas or oil with gas and it is expanding, this can cause a cooling effect. These temperature fluctuations can be easy to spot and should warrant further review of the zone.

Differential Temperature is sometimes included on logs. This is the change in slope of the temperature line. It can basically be used the same as the temperature only it will have a more vertical line.

Our example log has the differential temperature. It is below 0 until it gets to the zone (2302'-2310'). It then it moves to the right, above 0. This log can make it easier to see the temperature change.

F. Caliper

The caliper is logging tool that will measure the size of the hole. It uses three arms that ride on the sidewall. There are often mud cakes that build up on the sidewall as well as washed out zones. This information will be used for several different things. If there are mud cakes or other obstacles (bridges), care may need to be taken with running casing or other tools in the hole. If there are washed out zones, the logs may not be good. A washed out zone can give a very high porosity reading when really the formation does not have a high porosity. It may also be difficult to get sidewall cores from a washed out zone. Also, cement calculations can be adjusted to take into account the washed out zones.

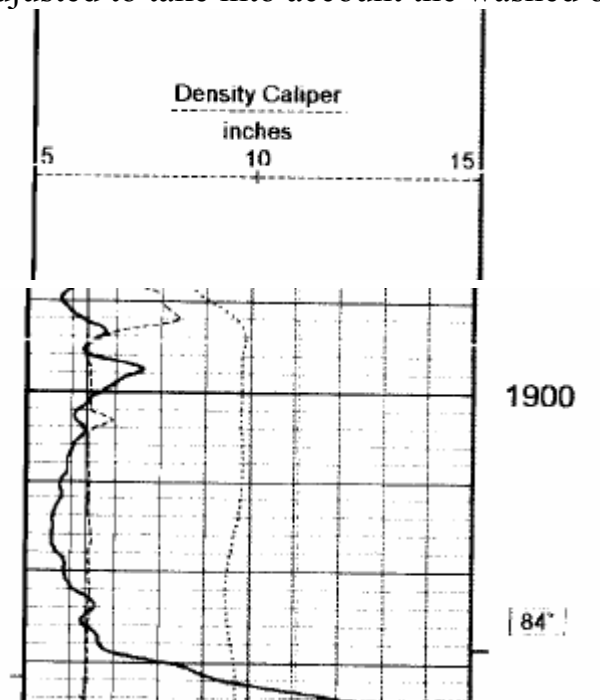


Figure 7

In Figure 7 you can see the caliper of our example log. At 1892' the caliper shows the hole is 8 1/4". Since this is the bottom of the surface hole, that makes sense. The caliper then shows the hole to be 6 3/8" at 1895'. The log has a line at 6 3/8" as this was the size of the bit. The caliper stays very near this line in our example.

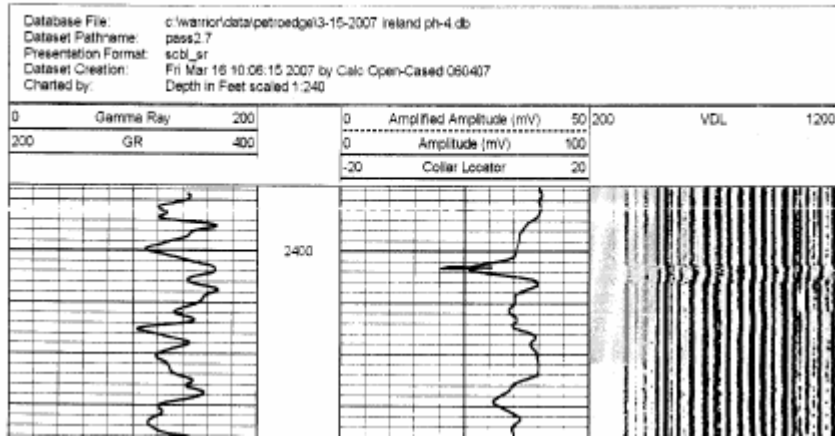
The caliper will also help centralize the tools in the hole.

8. Cased hole logging

Cased hole logs are run after casing has been run. There are a number of different logs that can be run through casing.

Most of the time, the logs that are run after the casing are used in the completion of the well. For the purpose of this class, these are the logs that will be covered.

For our example well, a cased hole log was run. It has Gamma ray, CBL, CCL and VDL. We will discuss each of these.



A. Cement Bond Log (CBL)

The CBL is a log of the bond between the casing, cement, and formation. The tool is basically a different version of the sonic tool. It has a transmitter and 2 receivers. One receiver is about 3 feet below the transmitter. It is used to determine the Δt for the casing. This will give the CBL. The second receiver is about 5 ft below the transmitter. It is used for the variable density log (VDL). The CBL is typically presented in track 2 with amplitude increasing from left to right. Basically, if the amplitude is low, the cement is good. If it is high the cement is not.

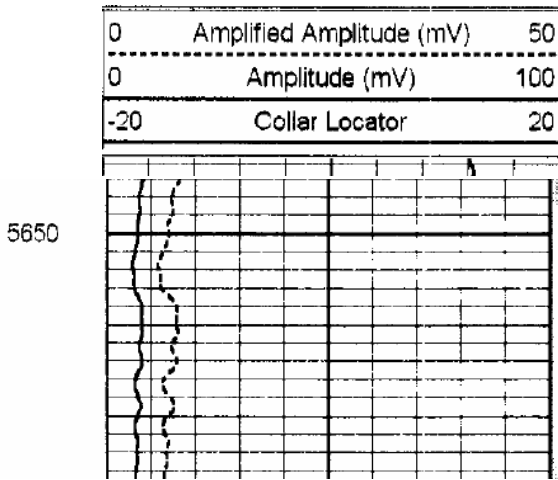


Figure 9 - Good Bond

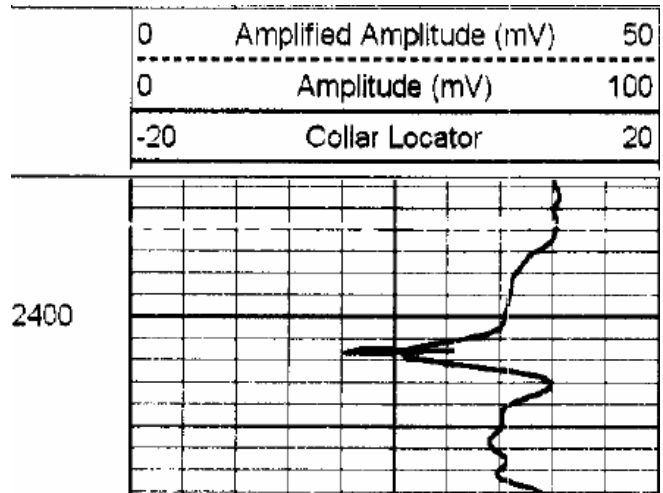


Figure 10 - No Bond

B. Variable Density Log

The variable density log represents the cement to formation bond quality. Sections without bonds will appear as dark parallel lines as in Figure 11. When the bonds are better, the lines will be lighter as in the figure on the right. This should correspond with the CBL.

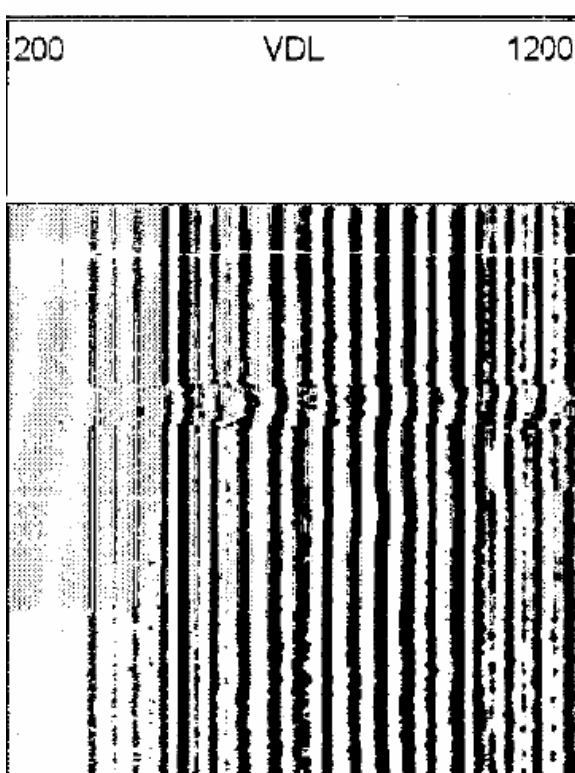


Figure 11

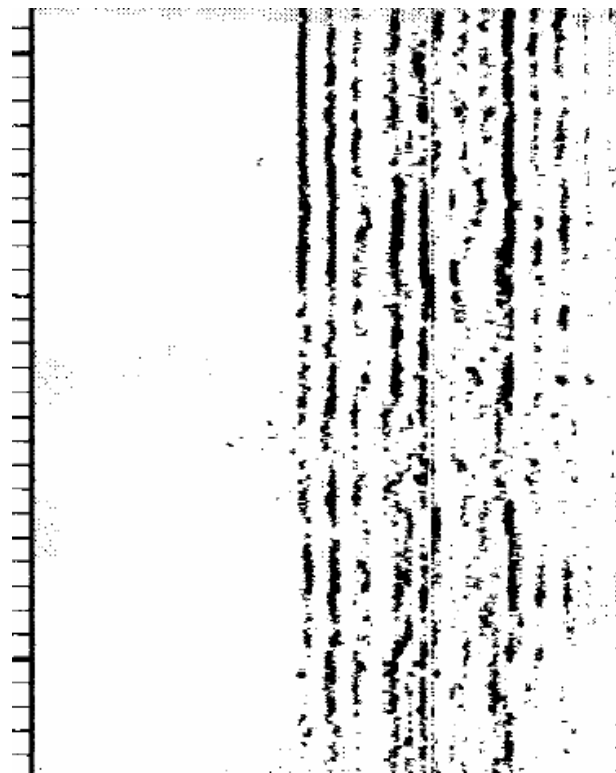


Figure 12

It is important to note that casing will expand when pressure is placed on it. If pressure was left on the casing after the cement job and there was no pressure on the casing during the bond log, the casing may have pulled away from the cement creating a micro-annulus. This will affect the bond log. Often bond logs are performed with pressure on the casing. This will make the bond log look better because the casing will be pushing against the cement. This will also reduce any microannulus. A microannulus can become a problem during completions or production so if they do exist, the problem should be addressed.

C. Casing Collar Locator (CCL)

The CCL is a fairly simple tool. As a magnet is passed through metal it will create an electrical current. If the metal is thicker at a point (as a collar in the casing), the current will fluctuate. This measurement will leave distinctive marks on the log. In Figure 13 the CCL is showing the collars at 3156' and 3198'. These are 42' apart, which is a common joint length.

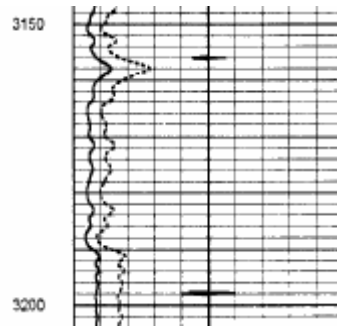


Figure 13

9. Log Correlation

Logging equipment is not always extremely accurate when it comes to depth. It is not uncommon for one truck to the next to be 10' off at 5000'. Even from one log run to the next with the same truck the depths may not exactly match. It is therefore necessary to correlate the logs so that the depths are consistent.

The first log that is run in the well is usually the official log. All of the subsequent logs will be correlated back to this one. If the first log is later found to be 10' off, it is still considered right.

The typical scenario where the logs will be correlated is during perforating. The original openhole logs are run. Casing is run and cemented. A cement bond log (CBL) is run with a gamma ray and casing collar locator (CCL). The next step is to perforate. The perforations need to be as close to the target as possible.

We will work through our example logs to set up the perforations to be at 5925' to 5945'. Figure 14 is the cased hole log. Figure 15 is the open hole log.

- a. The logs will be printed out at the point of interest. If the most recent log is on transparency paper it will be easier to see, but a light under the logs will also work.
- b. Pick a point on the gamma ray from the original log near the target that will be easy to identify. In the example, we would pick the spike at 5947'.
- c. Place the most recent log over the original so that you can see the original underneath.
- d. Line up the gamma ray so that they match. The readings will be a little different, but the overall look should be the same.
- e. Write some reference point on the log so that you will know what the depth should be at that point.
- f. The wireline operator will adjust the log to the correct depth.

- g. The adjusted log will need to be printed for the entire section that will be perforated. If there are any marker joints, they need to be on the print.

Marker joints are short joints, usually 5' or 10' that will show up easily when the CCL is run. They are a good way of checking the equipment while perforating, but not a necessity.

- h. Review the new log to gamma ray matches on both logs, checking multiple points.
- i. Place them side by side and make sure they match, checking multiple points. Be certain you are right.
 - If the perforations are a long distance apart and/or the perforations need to be precise, it may be a good idea to correlate the log at multiple points.

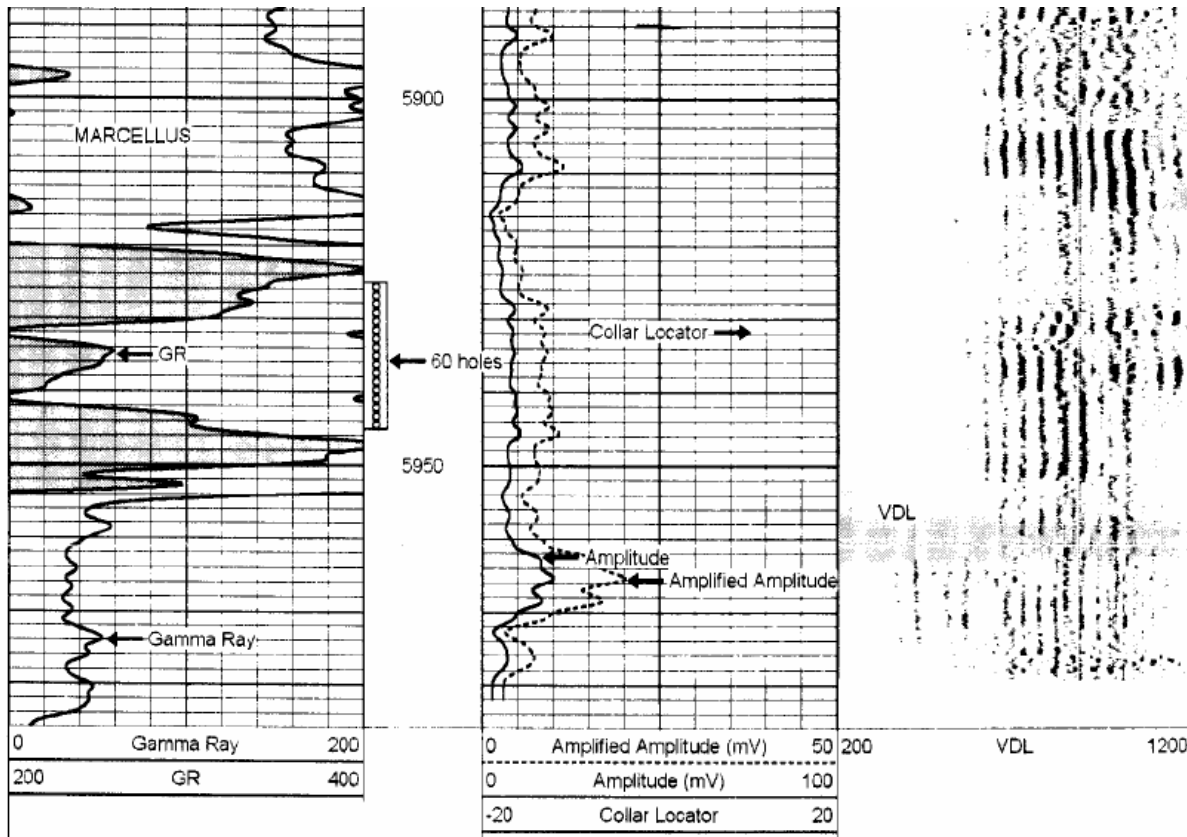


Figure 14

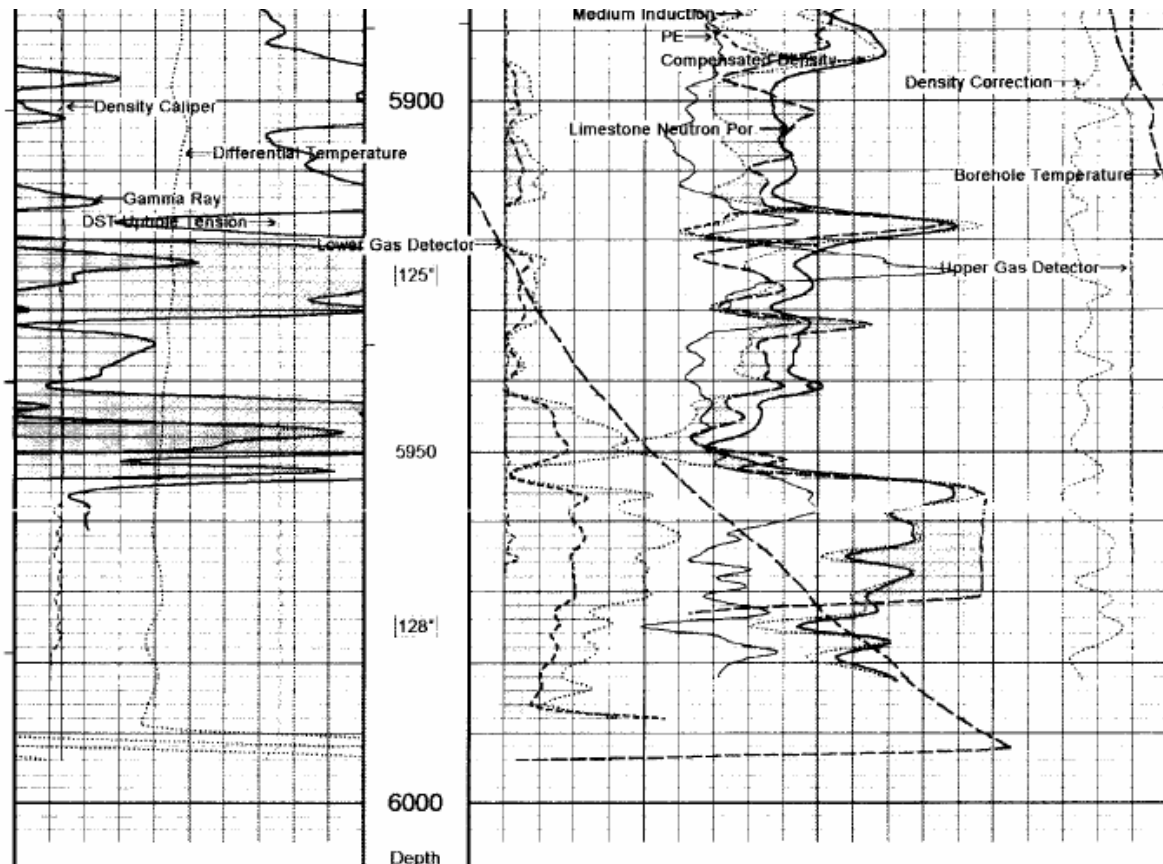


Figure 15

10. Perforating

Perforating is the process of shooting holes in the casing to gain communication with the formation. Basically, a tool is lowered with a wireline into the well at the right depth. An electrical current is placed on the wireline. The electric cause the shape charges in the tool to ignite and blow a hole through the casing, cement and into the formation (if everything goes right).

Before the well can be perforated the log needs to be correlated with the original. It is also a good idea to review the bond log to make sure it is good. The cased hole log should have the CCL marking the collars.

The perforating guns are made up to the wireline. The guns are lowered into the well. A CCL tool is above the guns. This will give a reading in the logging truck. When the tool passes a collar, it will move the needle on the gauge. The tool will be run to the marker joint. From the depth of the marker joint, the depth will be corrected. If no marker joint is present, then a collar can be used.

The wireline will be lowered to the zone to be perforated. When the operator is confident everything is in the right place, he will fire the guns. The tools are then

pulled out of the well. They should then be inspected to see if all the charges went off.

11. Pay Thickness.

The thickness of the pay zone can be fairly difficult to determine. If the formation is 5' thick and have tools that are reading every 2' or even every ½', there can easily be large errors.

Referring back to our example, from 1868' to 1884' appears to have gas, but is also wet. There is also no temperate kick. All in all it is probably not a good section. From 1886' to 1894' the zone looks much better overall. From 1900' to 1935' have potential, but the bottom part of it is wet and the top has a low porosity. When the zone is completed, likely all of it will be exposed. So what is the pay thickness? It can be estimated somewhere between 0' and 65'.

There are a few corrections that can be made with the chart books with various logs. That would be a good place to start.

12. Repeat Section

Well logs are based on several sophisticated, complicated tools. They break, become inaccurate and otherwise fowl up. One standard practice is to re-log a section of the well. This is called the repeat section. It serves to verify the logs are consistent. It may be reading wrong, but at least you will know it is consistently wrong.

First a section of the well is logged, and then it is logged again. The two logs should be identical.

12. Repeat Section

Just kidding.

13. Production Logs

Production logs are run after the well is completed. There are a few different types of tools that can be run. They can work for producing or injection wells. They can be run on wireline, slickline, or on coil tubing.

Temperature logs are useful in determining where flow in the well is coming from. Possibly it can be used to determine flow in the casing annulus.

Flowmeters or spinner surveys measure relative flow rates in the casing. As they pass producing zones, the rate that the spinner is moving will reduce. The result is each zone will have an estimated percentage of production.

Tools can also be used to determine pressure at various depths. A zone of interest may be isolated with packers if needed.

Smart Plungers are tubing plungers with built in measurement devices. While most may not consider this data as well logs, the data can be very valuable and should be noted.

Common tubing plungers come in many different designs, but basically they are cylinders that travel up and down tubing. Typically they are used to remove liquids from the well using the well's pressure. They operate similar to a pipeline pig.

Smart Plungers will typically record temperature and pressure, but new things could be added in the near future. This data is mostly used by production and reservoir studies. The data can be used to obtain bottomhole pressure and temperature, possible tubing issues, or to determine the optimum method to run a tubing plunger.

14. Specialty Logging tools

A. Gas Detectors

Our example log has gas detectors, which detect gas. They are just one of the many tools which can be used to identify productive zones.

B. Logging While Drilling (LWD)

This method of logging is used mostly during directional drilling or while drilling in high profile areas. The logging tools are built into joints of pipe that can be added to the drill string. They have to be able to handle the rough drilling environment so there are a limited number of them that are typically run. Many operations will use just the gamma ray.

Data is sent to the surface through mud pulses or electrical signals. With the mud pulse, data is transferred slowly, so it is important to be sending only data that is needed.

In directional drilling, the data is used to determine the position of the hole in relationship to the formation. This way the drillers can determine the optimum direction to drill.

C. Sidewall Cores

While sidewall cores are not logs, but the cores are taken with logging equipment at the time of the openhole log. In this process, cores are taken from the side of the wellbore with the wireline equipment.

There are two methods to take the cores. One is to use a rotary drill to drill out cores. The cores are drilled and stored in the tool.

The second method is to use a charge to shoot a hollow cylinder into the sidewall. Overall the operation is very similar to perforating. The tool will take several cores at the same time. The cores come to the surface in the cylinders. While this method is quicker, in weak formations like shale the cores may not be very good quality.

D. Micro-seismic

Micro seismic studies can be done with the use of logging type equipment. The tools are placed in a well. These tools will measure the waves similar to surface seismic equipment. The micro seismic can be used to view frac jobs on offset wells or a small seismic study.

E. Cameras

There are times when you need to see a picture of what is downhole. If the well is filled with a gas, there is a chance that a camera can be used. These cameras are run on wireline just like any other logging tool. They can be used in open hole or in cased hole.

15. Summary

Well logs are used to help evaluate formations that wells penetrate. They are a vital part of the oil and gas industry.

While this course only hit the highlights of the practice, there are many key points it covered. There are many types of logs that can be run in wells. The ones discussed in this course will help identify the type of rock, the porosity, water saturation, and if there is production.

The best way to become good at interpreting well logs is to do it. It will also be helpful to discuss your interpretations with other professionals.