Petroleum Reservoir Engineering

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Lecture – 2

Petroleum Reserves

Hello everyone. Welcome to this MOOCs course lecture, Peak 1, Lecture 2. In the previous lecture, we discussed about the conventional petroleum production system. In this lecture, we are going to briefly discuss about petroleum reserves. Remaining time of this week, we will be discussing about petroleum geology and drilling fluid methods. So, the petroleum reserves are the deposition of the organic and the rock material underneath the surface.

So, the picture that I have shown in the last lecture also is the surface picture where the deposition of similar kind of this data is shown. Where the time temperature history underneath the surface converts the organic material to hydrocarbon fluid. This happens over the geological time scale where the organic material converts into coal, oil and the natural gas. The other picture shown here is the representation of how these hydrocarbon fluids are stored under subsurface.

For deposition of this hydrocarbon fluid, source rock, reservoir rock and cap rock are required. So, the setting of geological formation and the types of the rock actually determine the hydrocarbon fluids are stored there or not or what are the composition or the phase of that hydrocarbon fluid underneath the surface at the geological reservoir formation. So, petroleum reservoir may be defined as a subsurface distribution of the pore network formed between a state of sedimentary rock formation which consists of hydrocarbon fluid and the water. Water is always associated with the hydrocarbon fluid. This petroleum reservoir underneath the surface is having the pore connected to each other and the path is permeable.

So, the geological formation is having the porosity and permeability because of that significant amount of the recoverable hydrocarbon fluid are stored at a place where we need to reach by drilling and collect this fluid to the surface. So, the reservoir are defined by their location, temperature and pressure. I mean to say the particular type of the reservoir may content of the hydrocarbons or may not content even if it contains how

much quantity it contains it depends at what location these reservoirs are deposited under what temperature pressure conditions these reservoirs are exposed. In geological terminology it is geological trap configuration, structure and stratigraphic features are the important parameters those determine the nature of the reservoir. Overall petroleum reservoir can be classified into three parts that is the proven reservoir, probable reservoir or the possible reservoir.

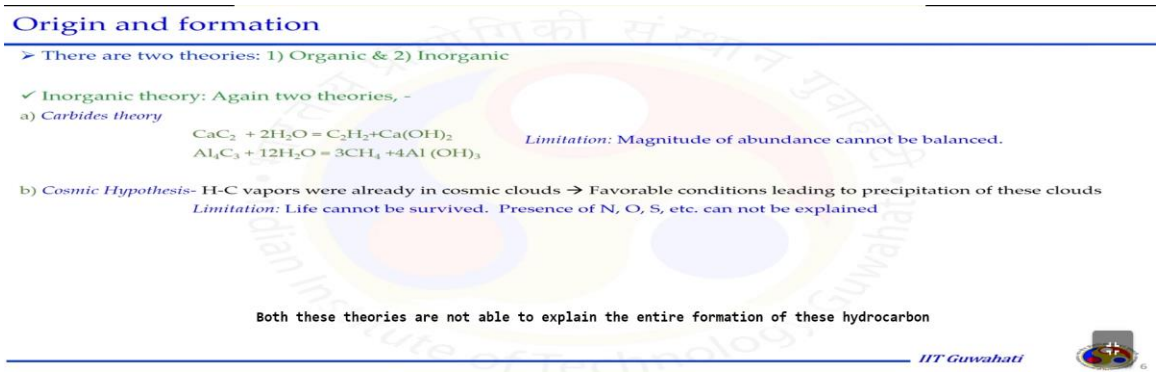
Proven reservoir are the reservoir which are producing at the economic conditions. So those are having the hydrocarbon fluid those are identified the drilling is done production started and those are producing at a high flow rate and the process is commercially recoverable. Hydrocarbon fluid that is called the proven reservoir. Probable reservoir these are the unproved petroleum reservoir which are having the hydrocarbon fluid and those hydrocarbon fluid can be recovered. So it is more likely than not to be recoverable those kind of the reservoir are called the probable reservoir and the possible reservoir are the geological side which are having the hydrocarbon fluid but those are not likely to be recoverable with the existing operating methodology some specific technology intervention is required to recover those kind of the reservoir.

If we discuss this in the broader perspective so the reservoir location is identified drilling is done and the estimation of the hydrocarbon fluid is performed. This called the OOIP original oil in place. So let us see the reservoir is having 100 percent OOIP that is going to classified as reserve that is recoverable or not recoverable. By the primary or secondary recovery, we can recover the reserve up to 34 percent and the unrecoverable oil is around 60 percent. So the reserve that is recoverable further can be classified as proved reserve probable reserve or the possible reserve that we just discussed or more elaborative we can say the proved reserve or the recoverable reserve probable reserve they are less certain than the proved reserve and the possible reserves they are probable and more likely not to be recovered additional things need to be done.

So once it is estimated about the recovery process of these hydrocarbon fluid the field are developed so the field can be classified those are developed field or under development and the developed field produces the production of the hydrocarbon is classified as produced or non producing hydrocarbon fluid. The other path could be where for the unrecoverable hydrocarbon that is actually the target for the EOR or tertiary recovery process where the specific type of the mathologeria technique is adopted to recover the unrecoverable hydrocarbon from this reservoir. So, what this hydrocarbon fluid is we called it as petroleum so the word petroleum is a Greek word break down into two parts Petra that means rock and the oleum means oil. So, the petroleum can be called or petroleum means is rock oil it is a complex mixture of hydrocarbons with minor amount of the oxygen nitrogen and sulfur compounds. Hydrocarbon present in the

petroleum substance ranges from C1 methane to C40 or even higher up to C70 or even the more complex system where the hydrocarbon are having the carbon number beyond the 70 also.

In terms of the elemental composition this petroleum is predominantly having the carbon supported by the hydrogen 11 to 14 percent is the hydrogen and the remaining are the other gases or other substance. So, the petroleum in general that is the oil means crude oil and the gas that is natural gas are more homogeneous in terms of the composition than in the coal and this petroleum are formed in the sedimentary rocks. So, when we talk about the coals there are a variety of the coals depending on the elemental compositions or the proximate and ultimate analysis, we can classify them as ignite coal means bituminous coal and some other. So, petroleum substance are more homogeneous than the coal. How these petroleum reservoirs are formed there are various theories there broadly we can classify those theory as the organic and the inorganic theory.



Inorganic theory again there are many inorganic theory two widely published theories are carbide theory and the cosmetic hypothesis. Both these theories are not able to explain the entire formation of these hydrocarbon things there are certain limitations. So for example in the carbide theory the mineral carbonate reacts with the water and form the hydrocarbon substance like C2, H2 and those go through the further chemical reaction to form the higher molecular compound. But this carbide theory is having the limitation because the amount of the hydrocarbon reserves are formed across the globe cannot be explained with this kind of the hypothesis. Because abundance of the hydrocarbons are formed and these carbide reactions are limited they require the water to be formed and the metal carbide should be enough to form that amount of the hydrocarbon.

The organic hypothesis that says hydrogen carbon vapors are already in the cosmic clouds favorable conditions happen and because of that we got the hydrocarbon. But this is also having the limitation if that kind of the clouds were present the life cannot be survived on this planet and presence of the hydro atoms like nitrogen, oxygen and sulfur cannot be explained with this theory. The organic theory that is most widely accepted

theory where the large marine animals is the main source of the fat that fat got converted into hydrogen. But this hypothesis again cannot explain the presence of the nitrogen so more comprehensive approach on the organic theory was proposed that is the combined organic theory that says the initial deposition of vegetable and the animal matter was a result of activity of the microorganism that is we call the thermophilic bacteria effect and later on this organic matter that is got deposited underneath the surface gone through the pressure and temperature profile and converted into hydrocarbon float. In general the organic matter that is underneath the surface got trapped over the geological time scale gradually converted into coal, oil and the natural gas.

Two types of the organic matter are found in the rocks those are land derived and the aquatic life based organic matter. These matter underneath the surface means several thousand feet depth are exposed to heat and pressure that is converted this organic matter to a substance called the human and then this human got converted into corrosion. The process of converting organic matter to the corrosion is called the diagenesis process. Over the time as the corrosion is left there underneath the surface over the time and temperature this corrosion got converted into petroleum substance this process is called the catagenesis process. So, what this corrosion is? Carosene is a sedimentary organic constitute of sedimentary rocks that is insoluble in the usual organic solvents.

Carosene are composed of variety of the organic material that may include algal, pollen, board, bitunite materials. The types of the corrosion broadly corrosion is classified in three-way corrosion type 1, type 2, type 3 based on the elemental analysis. But the types of the corrosion that is present in a particular type of the rocks control the types of the hydrocarbon fluid those are going to be produced by this rock. Overall, over a long time the influence of the temperature and pressure converted the trapped organic material by biological, biochemical and thermochemical processes to the formation of the hydrocarbons that hydrocarbon is oil and gas. So, if we classified this hydrocarbon fluid.

So, the hydrocarbon fluid that produced from this reservoir is having a very complex compound mixture primarily hydrogen and the carbon in different proportional. Hydrocarbon will exit in a fluid phase or in the solid phase when it is in the fluid phase it is gas and liquid when it is in the solid phase either it is the corrosion, bitumen or the coil or the coal depending upon the organic material is exposed to different time temperature history. Broadly classification of the fluid hydrocarbon could be the liquid hydrocarbon and the natural gas hydrocarbon there should be gas. The liquid hydrocarbons are further classified as the crude oil, natural gas liquid, natural gas liquid is further classified as condensate gasoline and the liquid petroleum gases. Similar way can be we can classify the natural gas as the non-associate gas, associate gas and dissolved solids gas.

So, these are the form of the fluid phase that is getting produced from the reservoir naturally broadly these are the crude oil and the natural gas, but further classifications are there. So, when we talk about the liquid hydrocarbon what this crude oil is? It is a mixture of hydrocarbon that exit in the liquid phase at the reservoir condition as well as when we are bringing this to the surface the temperature pressure is different at the surface it still remains in the liquid phase. The substance or the fluid phase is called the crude oil. What is the difference between crude oil and the natural gas liquid? The natural gas liquid is that portion of the reservoir gas that are liquefied at the surface. So, the natural gas liquid NGL is actually in the gaseous phase underneath the surface when it is brought to the surface it is passing through the separator surface facilities or processing unit it changes its phase and convert it into liquid that we call the natural gas liquid.

Natural gas liquid include but are not limited to very light hydrocarbon gases like ethane, propane, butane, pentane depending on at what temperature pressure they are exposed they may get converted into liquid phase including the gasoline and the condensate. Similarly, we can say about the natural gas also natural gas is a mixture of hydrocarbon and non-hydrocarbon gases that exist in the gaseous phase or in the solid sun with the crude oil underneath the surface at the reservoir condition. The subdivision of the natural gas non-associated gases this is kind of a gas that is free gas that do not contain any significant quantity of the crude oil. It is in the gaseous phase underneath the surface when it is brought to the surface it is in the gaseous phase. Associate gas that is also known as a gas cap gas which actually settle underneath the surface and in the reservoir formation above the oil and it is getting produced along with the oil.

So, it is always associate with the oil production. Dissolved gas is the portion of the natural gas that is actually is in the solid sun phase with the crude oil under the reservoir condition. Another terminology for the gas dealing with the reservoir is the injected gas. This is the gas we injected in the reservoir from the outside to maintain the pressure in the reservoir. So, why it is important to discuss this crude oil and the natural gas? As we already know about the importance of the crude oil and the natural gas or the fossil energy actually the fossil energy is still are very important source of the fuels.

They actually control the world economy. If we look the utilization of the hydrocarbon fluid or the reservoir fluid in the sector wise like the transportation, industry, non-combustion things and the building we will see the demand of end users in different sector is keep increasing. So, the data shows here are from 1970 till 2040 so the projected data. These kinds of the data you can find in several agencies. Those are producing such kind of the data almost every year like the Energy Outlook, CIA, EIA.

The data taken here are from the BP Energy Outlook. They published in 2019 where it shows like the end user sector for the energy demand is increasing. This is happening because the rapid development is happening, civilization is going through the modern phase and the energy demand is required. The energy demand if we look in the reason wise, we also see the energy demand or overall energy demand is also increasing worldwide and it is expected in 2040 the energy demand will be higher or significantly higher compared to 2019 where this data is taken. In this chart we also see the country wise or a group of the countries that form the organization of economic cooperation and the development around 38 countries are the part of this.

They are in the need of significant amount of the energy. India need is lesser than the China and some other African countries are having the need but in general we will see each country's energy demand is increasing as we are progressing towards the development. How to meet this energy need? There are several forms of the energy. Those can be utilized to meet this need. They can be classified as renewable, hydro, nuclear, coal, gas and the oil.

So in the third graph you will see the energy is supplied in different forms like renewable, hydro, nuclear, coal, gas and their distribution is on how much share they are having in the total supply of energy need. The BP energy outlook in 2019 published the data and they said 50 percent of the demand of the total energy need of the world is still be supplied by the oil and gas until 2040. Despite the oil breakdown happened in 2015 the demand of fossil fuels like oil and gas in the world is still high. World is still depending on the fossil fuel waste energy. When we look some oil reserve scenario worldwide a global proven oil reserve have been recorded to be around 1734 billion barrels in 2019.

I said the data are taken from 2019 published by energy outlook or some other agency. You can find out the updated data every year. Certain agencies publish the data every year about the world global perspective of the energy, different shares by different sector of the energy. Sometimes the data are like not accurate because it depends on how much data they collected, who provided the data, how accurate those data are as well as the world is moving with a faster rate. So the share of different sector of the energy may be changing.

Similar to like petroleum reserve when we are classifying the petroleum reserve in the proven probable and the possible the distribution may change because if the new discovery happen the total oil reserve of a country will also change and that will reflected in these classification of the petroleum reserves. Let us come back to the world's oil fields. So, the global proven reserve is 1734 billion barrels. The global reserves to

production, so how much reserve a particular country is having or globally how much total reserve and how much we are producing shows that the oil reserve in 2019 is enough to supply the current production rate for the next 50 years. If we keep producing with the current rate next 50 years the reserve is good enough to supply the hydrocarbon fluid.

If we look regionally South and Central America have the highest RYP ratio that is the reserve to production ratio and they can produce up to 144 years while the Europe has the lowest and their reserves are estimated to produce up to 12 years with the current rate they are producing. The top countries in terms of the reserves are Venezuela that is accounting 17.5% of the total global reserve followed by Saudi Arabia 17.2% and then Canada and then that is around 10% then the rest of the countries comes in terms of the total reserves. The organization called the OPEC, organization of the petroleum export countries.

This is the organization of the inter government of 30 nations founded in 1960 in Baghdad by its first member then they later on increase the numbers of their member. Its headquarter is in Vienna now since 1965. So, these 13 countries actually formed a group called the OPEC and the OPEC is having a major influence on the global oil price. The OPEC includes six countries from the Middle East, one from Southeast Asia, four in Africa and two from South America and some of the countries are the permanent members some are on the rotation. As per OPEC annual report published in 2019 around 80% of the total proven oil reserve is located in OPEC member countries.

So they actually controlling the price, they actually controlling the production and the business of oil related or they actually controlling the oil related business. If we look on the proven crude oil reserve for different countries, so I summarize the data for 3 years 1990 after 20 years 2009 and then another 10 years that is 2019. You will see more or less the data are showing the constant distribution slightly changes there. For example, in the Middle East in 1990 it was 53.75% of the total proven reserve was in the Middle East that is come down to 49.

25 in 2019 and 2019 it was 48.15%. More or less if you see the data are almost constant, slight variation is depending on how new discoveries are happening at what rate they are producing, how much reserve remains with them. In this list of the global perspective published by again BP Energy Outlook in 2010 we will see the Benidjola that is having the highest reserve followed by the Saudi Arabia 298 billion barrels followed by Canada, Iran, Iraq, Russia, Kuwait, UAE, United States and the Libya. In this list if you see India is somewhere here which is having the very less amount of the reserve compared to the world total reserve. But in this picture the Benidjola is actually leading in terms of the

proven reserves in billion barrel but despite having the biggest proven world oil reserves in the world the country Benidjola is falling at 14th position in terms of the world oil production as per the OPEC data 2017. So, it is not just you are having the oil reserve how effectively you are able to produce that oil reserve is also important.

Apart from political and regulation reasons a big reason is that the oil is very difficult to extract. So, the oil reserves are there but the composition or the quality of the oil reserve depends on the geological setting and the other parameter. Sometimes the oil is there but it is very heavy or it is very viscous it is not easy to recover that is one of the case with the Benidjola. If we see the production and the consumptions worldwide there is a constant increase in the world need of the fossil energy or the crude oil this picture shows for the crude oil from 2000 to 2018 you see the production is also increasing to beat the consumption rate. It increases from 77 to 98 billion barrel per day from 2000 to 2018.

If we look the Indian scenario the production and consumption are getting apart as we are moving further from 2000 to 2016. So, the production is not happening at the rate at which the consumption is happening in India for the crude oil. It means India is heavily dependent on the import. If we look reason wise where this crude oil in India that is getting produced locally in India we are having the 52.29 and around 28% of the oil reservoir mostly in the eastern offshore and the Assam region and the other regions are having the distributed like Andhra Pradesh, Gujarat, Tamilnadu they are also having some share but majority of them are in the eastern offshore and the Assam region through which the production is happening in India.

In terms of the different classification of the reservoir the proven reservoir in India those are producing commercially are in Combe, Bombay, Rajasthan, Assam, Assam, Arc and Folt belt. There are potential reservoir also in India and there are several sites those have been identified and they are having the probable reserve like the Kutch, Ganga basin and Kerala, Konkan basin and some other Bengal basin. So, India is also having the possibility to increase its proven reserve in the future if this probable reserve could be converted into proven reserve. Some more data on oil consumption, production and import in India.

So, the oil consumption in India is 44 or 4.4 million barrel per day. India ranked third in the world in terms of the consumption and that is a count 4.6% of the world's total consumption. India consumes 0.14 gallon of oil per capita per day that is approximately 51 gallons per capita per year and these data are from year 2016.

So, the current value might be different. So, when it comes to the oil production in India, India is ranked 20th in the world in terms of the oil producing country. India

produces every year an amount equivalent to 7.8% of its total proven reserves. So, to meet the need, India heavily dependent on the imports and 96% of the oil consumption India is having is imported from the other countries. By the end of 2019, India has reported a total proven crude oil reserve of 4.

7 billion barrels. Some more data on Indian wells. They are as deep as 12,000 feet and can yield as small as 200 barrel per day to 3000 barrel per day. Indian crude oil is having the API value in the range of 45 to 70. Two major players in India, ONGC and OIL, they are in the exploration and production. To produce the oil, identify the new site and finding out the potential reserves. On the private side, we are having the Reliance, Cairns, Shell, Heli Burton, Schlumberger and many more players.

Those are actively looking different sites to find out the hydrocarbon reserves. With that India's proven reserve or the potential reserve may increase. When it comes to the market value of the crude oil, crude oil are categorized in different form. One of the way the crude oil price is controlled in the international market is quality of the crude oil. That is the amount of the sulphur in the crude oil as well as what is the API gravity of this crude oil.

These are the two important parameters. Sulphur content, that is if sulphur content is more, it is sour type of the crude oil. When the sulphur is taken out, it is sweet or when the sulphur content is less, the oil is sweet oil. In terms of the API gravity, it ranges from heavy to light oil. So, the oil price depends on sulphur content and the API gravity. If the API gravity is light or the value is high, then we are having the better quality of the oil.

Similarly for the sulphur content, if sulphur content is less, the crude oil is having the better value in the market. Like two types of the crude oil, light Luciana sweet or West Texas intermediate, they fall in that category where the sulphur content is less and API gravity is reasonably towards the lighter side. So, they are having the better market value. So when it comes to the composition of the crude oil, crude oil is a black oil in color with following majorly in eight groups of the hydrocarbon that we can classify as paraffinic, cyclopentane, cyclohexane, cycloheptane, dicycloparaffinase, benzene, aromatic cycloparaffinic and dinuclear and poly nuclear aromatic compound. Overall broadly we can say crude oil is having the hydrogen, carbon along with some metals, some heteroatoms into it and some inorganic compounds like some ions into it.

A smaller amount of the organic compound like sulphur, oxygen and nitrogen are always present in terms of the heteroatoms in the crude oil. More smaller amount of the compound like the metals are also associate or the organic metal compound are also

associate with the crude oil composition. So, this crude oil is complex. Physical and chemical properties varies depending on the geological formation we are extracting this crude oil. Broadly we can classify in three part like open chain or aliphatic compounds.

Those are normal paraffin series CN, S2N plus 2 or isoparaffinic series. Second is ring or cyclic compound. Those are naphthalic or the aromatic compound. Those are the close cyclic compound either in the naphthalenic form or in the aromatic form or the asphaltene or the asphalts.

Those are asphaltene or the resins. They are the heavy compounds in the crude oil. For example, the resin it is highly adhesive, brown in color and lower molecular weight with respect to then asphaltene they are present. So, if we do the SARA analysis of the crude oil, we can classify the crude oil into aromatic, saturated aromatic, asphaltene and resins. Asphaltene resin are the heavy or higher molecular compounds. So the paraffinic based compound predominantly are the open chain compound give low grade gasoline and the baxi-luvoyl.

Naphtylene compound they are the cyclic compound predominantly asphaltene is also present and Indian crude oils are having this kind of the composition. Intermediate base, large quantity of both paraffinic and naphthalic compounds they give the bax and the asphaltene when we are processing this crude oil. So, the crude oil composition can vary. They could be in the cyclic form, isoparaffinic, paraffinic, aromatic compound and can vary that I mentioned like they can vary to a very low carbon number C12, very high carbon number up to C70 and something. Crude oil what we use like the gasoline or the diesel, gasoline means the petrol and the diesel looks very light and transparent in color and all those things.

But in actual the crude oil is very thick and black and brown in the color. Some of the images I am showing you here how crude oil looks like. This crude oil goes to the refinery and get refined and different fraction of the crude oil, different fraction of the petroleum substance are produced in the refinery. The second substance of the hydrocarbon fluid is natural gas. Natural gas is a complex mixture of hydrocarbon with minor amount of the non-hydrocarbon compounds.

So predominantly it is from C1 to C6 or C7. In the non-hydrocarbon gases, it is carbon dioxide, hydrogen sulphide and the nitrogen. The gas or natural gas is colorless, odorless, it is combustible in nature, it produces energy when it is combusted and it is considered as a clean fuel as it is not going to produce some harmful gases like the SO2 and SOX and NOX. The energy content of the natural gas is measured in BTU. The value varies from 500 to 1550 BTU depending on the composition. So, if the

hydrocarbon composition or the higher carbon number, hydrocarbon composition are more, the heating value of the natural gas is more.

The non-hydrocarbon gases reduces the energy content of the natural gas. Other than the crude oil and the natural gas, most of the reservoir also produce the reservoir water that is also called the formation water or the produce water. The composition of oil reserve water depends again the reservoir formation, but oil reservoir water also known as conic water almost invariably contain dissolved salt. Conic water has more salt than the seawater. The analysis of water collected from the oil field source, it is having several type of the cationic and anionic substance.

The value for one of the sample collected from oil field are compared here. So, different composition ions and their comparison is done with the seawater. We can see even the some of them like calcium, iron, sodium, iron, magnesium, they are more than the seawater. So, overall formation water is more salty than the seawater. So, to reach this reservoir fluid, the exploration techniques are required.

The picture is shown here. It says like from the production well, we are producing the hydrocarbon fluid along with the water, but how this fluid is getting produced, we need to find the location where the well should be drilled. That means we need to do some survey to find out the exact location, not only the location, but how deeper that well should be drilled to get the hydrocarbon fluid out of the reservoir domain. For that purpose, exploration techniques are developed by the geologist and geophysicist over the time. And if we look in the history until the late 1970s, successful drilling was a hit and miss operation. So, geologists and geophysicist used to suggest there is a potential site where the hydrocarbon reserves may be found.

The success was not that high. Even the rate of 10% success, it means one good well and nine dry wells was considered to be attractive during that time. But as the advancement happens, a lot of geological surveys are done, seismic surveys are done, not only in 2D and 3D, now 4D seismic surveys are done. The underneath surface is also mapped properly to find out the locations and the deeper position to recover this hydrocarbon. So, these are done with several surveys, several techniques like magnetometer, logging the data and now advanced computing techniques are there where we can model the underneath the subsurface phenomena easily with as much as required or accurate information, perform the simulation to identify the position where the drilling should be done. So the geophysical surveys include seismic survey, gravity survey, magnetic survey, these kind of the survey actually record the physical properties of the subsurface formation.

These measurements translate the geological data such as structure, stratigraphy, depth, positions into useful information. Those are correlated to establish the relationship are those sites or the locations are having the reserve or not. If they are having the potential reserves, it is going to be the oil or gas or the mixture. The physical properties of rock are also documented to identify the potential traps in the reservoir and overall basin geometry configuration. So, these kinds of the survey are not only useful for the petroleum reservoir or is producing the hydrocarbon fluid out of the reservoir, but for several other purposes also, those are used by the geologist and geophysicist.

One of the techniques that is widely used for identifying the location is seismic survey. It involves the natural or artificial generation and propagation of the seismic waves down into the earth until they encounter a discontinuity and are reflected back to the surface. So the seismic survey is similar to the ultrasound, we go to the doctor and get the ultrasound done to scan out what is the structure in our body part. For example, we are going to get the scan of the stomach, how the kidney is functioning, is there any fatty liver or something or not. This is done in the similar manner in the seismic survey in the field where the electronic detector called the geophones are used to collect the waves those are reflecting back from the underneath the surface.

So the sound waves are generated with the help of some thumper, vibrations are created, those waves are propagating underneath the surface, they are striking to different formations. Based on the formation, they are reflecting back to the surface and the time taken or the velocity of the sound wave is recorded and that is correlated the types of the formation is present there. So, the seismic wave travels to non but varying velocity depending upon the kinds of the rock they are going to strike. The speed of sound waves through the earth crust varies, it varies directly with the density and inversely with the porosity. The seismic wave travels with the speed of minimum like 1000 feet per second and maximum 20,000 feet per second that is approximately 6 km per second.

The pecal average velocity in different rock if it is shell it is 3.6, sandstone is 4.2, limestone is 5.0 and similar for the other are recorded they are in the database where the different geological formation can be correlated with the help of seismic survey. So, in the summary of today's lecture, we discuss about the origin and the composition of the hydrocarbon fluid like crude oil and the natural gas, briefly discuss about the water, energy scenario, the demand and supply across the globe, the proven reserve in the world and in India. Exploration technique we will briefly discuss about the seismic survey only. More detail can be found in the literature about like how the logging of the well is done when it is getting drilled and how that information is transferred to the useful information.

In next lecture, we will discuss briefly about the petroleum geology of a reservoir. With this, I would like to thank you all of you. See you in the next lecture. Thank you very much.