

Lecture 02: Concept of Seismic Reflection, Introduction to Drilling

Hello and welcome to the second lecture of the course, petroleum technology. In this lecture, I will cover several topics, which are the concept of seismic reflection and the introduction to drilling. You might have remembered that we have made a small introduction to seismic reflection exploration data, those are called seismographic data logging. Here seismograph is an instrument which measures the shock waves from explosions initiated by triggering a small controlled charge of explosives in the bottom of shallow holes in the ground. A location is detected where people think that there is a possibility of a petroleum reserve. Their seismographic data logging is done by some charges. Explosion charges are put just below the surface of the ground and around this location, some detectors are also placed which can detect the sound waves. Now these explosive charges are triggered and they generate sound waves. Those sound waves travel outward in every location and every direction and some of those sound waves reflect back to the ground under the earth at definite types of rock structures. Those reflected waves are called acoustic waves. They are captured by some of the detectors placed on the ground and those reflection is assumed to be from the denser rock formation under the ground. This is a picture where there is a source of sound which generates sound waves and those sound waves are getting down to the subsurface and reflected back to the ground and captured by a receiver. So, this is a source of sound waves and this is the receiver. These receivers are actually called geophones, those are low-intensity microphones. Now whenever the sound waves reflect to the ground from the underground rock surfaces you see layer 1, layer 2, layer 3, 3 layer reflection is made here. The formation depth is determined by measuring the time elapsed between the explosion and the reflection of the wave. So this way, we can understand where the subsurface petroleum-bearing rock is there or the probability of having the petroleum-bearing rock underground. This is another type of subsurface seismic reflection method which is called the concept of common depth point in seismic reflection.

You see in this picture, we have several sound-generating sources and several geophones arranged accordingly and the sound wave generated by source S1 and traveling by the pathway S1 to R2 are hitting at the same point where the sound generated from S2 and following the path S2 to R1 hits. This is called common depth point and the power of the common depth point method is the multiplicity of data. That means, say, this is a subsurface bearing rock where we do this exercise for several points and for several points, we find several data for a single point. So, obviously, this process gives a multiplicity of data, and the degree of multiplicity is called CDP fold. The more the number of folds in CDP data, more strong the data at that point as well. As if, we can traverse the whole subsurface rock in this way, we get very detailed data about that

subsurface rock. Now, we are entering into a different topic which is the introduction to drilling operations. Once the exploration data are compiled together, they are analyzed individually, they are explained, and with some imagination as well as with some calculation, people determined to drill an exploratory well at the beginning. And this drilling of exploratory wells is related to a commitment of some hundreds of thousands or even millions of dollars. So, you understand that drilling operation is highly expensive and as well as drilling operation is a very complicated procedure. Before going to the drilling, first, people used to fix the drill site where the drilling should be made.

Drilling site choosing is also a very important process. The next one is whenever people will drill a well at that drilling site; it requires a proper well design, drill well design as well as well construction plan. If the plan is not good, the well may not be drilled properly, or the well maybe, may cave in. The next one is the decision to drill. A well only be made after exhaustive investigations of the petroleum prospects of the well whenever the exploratory data gives us the idea, that yes, at that position, we will get the commercial petroleum reserve. That means, after employing lots amounts of money and energy and effort behind drilling petroleum well, if we do not see that, we cannot recover the commercial amount of petroleum oil and gas which we can sell in the market and we can get a profit out of it, we cannot proceed for drilling. So, all these calculations are highly complex in nature as well as it needs experience and as well as it needs several imaginations as well. Now, the depth of drilling may vary from 3000 to 30000 feet. It may be a very deep drilling, or it may be a shallow drilling depending on the position of the reservoir rock under the ground. Now, you see that most of us may think that the drilling of a well may be a vertical one. In many cases, we see that the drilling of wells may not be totally vertical. It may be inclined and also may be horizontal depending on the demand. Now, you see the picture where you see the drilling is done. It is called multi-well platform drilling. So, several wells are drilled from a single platform which reduces the cost of drilling and you see one drilling well is vertical and others are inclined in nature. So, all these wells can take the oil throughout the whole area of the reservoir so that it can recover all the wells reserved within it. This is a highly economical process. The next types are this B and C are the inaccessible locations B and C. Whenever we see there is a mountain or city and underneath there is a prospect of petroleum reserve, we cannot dig at that position. So, we have to go for the inclined drilling. You see here there is the reservoir on top of which there is a maybe buildings and maybe some ocean ponds or lakes. It is better to go sideways and drill an inclined well. So, the well can reach the reservoir rock and can recover the oil from it; this is another type where we already have a reservoir rock from which we can recover the oil. This inclined drilling is also called directional drilling. Here you see we have drilled the well vertically as well as directly and there is a possibility of reservoir rock just by the side of it may be some 1 or 2 miles on the other side. So, from the same platform, we can drill another well that can reach that reservoir and can recover the oil from it. The fourth one is the horizontal well

drilling.

Here you see the well is drilled in such a way that the first part is the vertical one and the next part is the horizontal one. So, the well can sweep lots of area parts of the reservoir rock and the recovery is prominent. Now, coming to the drilling operation, some glimpses of the drilling operation will be discussed over here. Most of the oil wells are drilled by rotary method and the drill rig is used to drill the well. I have shown the drill rig here. This is part of the drill rig. You can see it is a large piece of equipment consisting of many parts in it which are labeled over here and the drilling is done by the rotary method. And there are several important components of a drilling rig discussed here. These are, first one is a power plant, the next is hoisting and rotary machinery, the third one is a drill column, the fourth one is a mud circulating system and there are several other auxiliary equipment associated with the drilling rig. The power plant is the most important accessory in the drilling rig as it runs the whole system. It supplies power to different points of operation and for this, the whole drilling operation goes on. Usually, it is seen that for a lighter rig that digs around 1000 meters of well depth, it requires a power of around light rig, which is around 1000 meters which requires power around 250 to 300 bhp. If it is a heavy rig that means it has to drill quite a long distance beneath the heavy rig, which can dig at around 4000 meters or more, it requires a power of around 2000 bhp. A mud circulation system requires a mud pump; a mud pump also requires heavy power which is around 700 bhp. So, you understand that a power plant is a very important part of the whole system. Now, let us come to the hoisting and rotary machinery. This is a part that hoists the whole system and it rotates the drill stem and drill bit for drilling purposes and the next one is drill column. A drill column is obviously necessary for the drilling and mud circulation system. Here, you see some parts of the drilling rig and mud circulating system. Mud is required. It is a necessary component of drilling here. Mud is circulated through the drill column for the easy drilling system.

Now, coming to the drilling bit. The drilling bit is an abrasive component that is fixed at the tip of the drill stem or drill string. Drill string or drill stem is that which actually goes inside the exploratory well and on the tip, when the drill bit is fixed, drill bit rotates and cuts the chunks of the soil and oil rocks inside and it goes down by this rotary method. There are two major types of drill bits used. One is the most popular and the most used one is the roller cone drill bit. It has the teeth which are steel teeth in which the tungsten carbide inserts are there, which strengthen the steel teeth and it acts with the grinding and chipping technique. Now, coming to a newer type of drill bit, which is a polycrystalline diamond compact bit or PDC bit. It has several small disks of synthetic diamond embedded on the head of the drill bit and the diamond is a very hard material, it has very high wear resistance. So it can cut the drill chunks or soils very easily. Now, after completing an exploratory well, when the steel drill string goes inside the drill well and the abrasive bit is there at the tip of it and we have the required depth of drilling already

done. The drill string and drill bit are taken out of the well, and into the well, and a steel casing which is a big steel tube is inserted into the well joint by joint. If it is a vertical steel, vertical well, the steel pipe goes vertically. If it is directional drilling, then steel pipe joints are bent according to the well direction. And after the steel casing is inserted, a cement slurry is poured into the annular space between the drill casing and the bore wall and around the annular space. And when this cement thickens or sets, it prevents the cave-in of the drill well as well as it does not allow to enter unwanted water, oil, or gas from another reservoir rock and it provides a return passage of the drill mud stream. Well, this makes a whole control on the well during the production. Now, coming to the workflow so, whatever discussion we have made till now, we can chalk out the workflow. The first one is the finding of a hydrocarbon reserve by exploration. Different types of exploring techniques are used over there to find the hydrocarbon reserve. And after finding, people have to do the designing of the production policy, which means, an optimum recovery, means, the commercial recovery until and unless it is not a commercial recovery, people do not go for that. Next is the planning of well spacing and development scheme. You know that petroleum reservoir rocks are spread mile after mile. So, what is the well spacing? If the well spacing is very narrow, if they are very close together, then the purpose of recovery is totally defeated. So, there should be an optimum well spacing required for the optimum recovery as well as we have to see the development scheme. Next is the implementation of the recovery scheme. Once the oil well is drilled, then how to recover the maximum amount of oil reserved within the reservoir rock that scheme has to be made. The next one is the performance monitoring and optimizing of recovery, which is totally technical. Once the drill well is formed and after that, when recovery is started, during this recovery how is the performance of the recovery whether we are getting the proper amount of oil and gas as we expected or not? What is the performance of the well, or what is the performance of the work during the production and optimization of the recovery. Now, how can we optimize the recovery, not a very large amount at a time or not a very small amount at that time? So, there should be an optimum amount of or optimum flow of oil and gas through the well on the top surface of the ground. And next is the determination of the future production performance of the same reserve or remaining reserve. Once we have produced petroleum oil and gas from a reservoir already, we see that some amount of petroleum oil may remain within the reservoir, which we cannot recover at that point or in that scheme, or there are several other reservoirs that we did not traverse. So, how does the plan for this future production performance of that already exhaust and some remaining reservoir rocks are there which we did not go at all or which we have taken the oil and gas, but not to a satisfactory amount? Next comes the information needed for the appraisal and development of an oil and gas reservoir. So, how to do it? We have to see the shape and size of the accumulation depending on the shape and size as well as the reachability of that reservoir rock, a plan should be made for the drilling. And porosity and permeability so,

permeability and porosity both give us an account of producibility, how much petroleum oil and gas we can produce from a definite type of reservoir rock, and how within the rock the porosity and permeability change, the variations within the structure. If within the structure the porosity and permeability data or properties change then obviously, we may have to develop a different plan of action for the recovery of the petroleum from that particular reservoir. Next is the nature of the hydrocarbon, nature of hydrocarbon if the hydrocarbons contained in that particular petroleum oil are light in nature that means, their molecular weight is low. So, the density and viscosity of the crude oil which we are going to recover is very low, then depending on the nature of the hydrocarbons, the approach to recover the petroleum will be different. And then the nature of the reservoir energy, reservoir energy is such that is also the type of the reservoir and how much it can allow us to recover the petroleum from it. Next is the cost of wells, pipelines, oil and gas prices, and so on. So, all these are economic data on how to get a well in a cost-effective manner which means, the cost of a well is obviously, this drilling operation very costly, I said as well after we recovered the petroleum from the wells we need the pipeline for the transport of the oil that needs a lot of money. Then all these are investment cost of wells, and pipelines all these are investments. Now what is the profit? that is the oil and gas prices, how much profit can we make by selling that oil and gas in the market and so on? Thank you for your attention.