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Petroleum Geology for Non-Geologists

Module Descriptions

Modules 1-8 explain the geological processes that lead to the development of a "petroleum system" in the subsurface.
Modules 9 & 10 address the oil and gas business and economic considerations.
Modules 11-15 describe the technologies and methods used to explore for oil and gas.

Module 1: Organic Source for Oil and Gas

Description: This module describes what the term "organic" means and how that term relates to hydrocarbons such as oil and gas. We dispel a common myth about the source of oil and gas and describe the seemingly-unlikely organisms that are the actual source. These organisms still exist today and we'll discuss the environments where they thrive and how their remains can be preserved by sediments. This will be important in later sections when we look back in time to see where organic remains may have been deposited and preserved in the past. Many of those deposits are sources of oil and gas today.

Module 2: Sediments and Sedimentary Rock

Description: Almost all oil and gas is found in "sedimentary" rock, and this module explains the natural processes that create sediments, as well as how those sediments become rock. You will learn about the major categories of sediments and will see magnified images of rock types to see how different they can be, and how they therefore serve differing roles in oil and gas. The material never becomes difficult or tedious, yet you will finish with a decent understanding of the rock types that are important to oil and gas such as shale, sandstone, limestone and halite/salt.

Module 3: Earth Changes Over Geological Time

Description: Oil and gas comes from source rock that is up to 500 million years old. The surface of the Earth has changed radically over that period of time due to a process called plate tectonics, so geoscientists must understand how the Earth has changed to understand where source rock may have been created in the past and where those sources lie hidden beneath the surface today. We'll discuss geological time, plate tectonics, and will take a look back in time to see how the Earth has changed. This subject is fascinating even if you're not interested in oil and gas.

Module 4: Rock Layer Characteristics

Description: Sedimentary rocks are created by natural processes but are also altered by natural processes. An understanding of these processes sometimes allows geoscientists to assemble a great deal of information about the subsurface from small surface clues. In this section, we briefly discuss general principles that geoscientists follow in evaluating rock formations. You'll never again think that rocks are boring when you understand the rich history that they can reveal!

Module 6: Oil and Gas Migration

Description: Many people don't realize that oil and gas has not "conventionally" been produced from the same source rock in which it was created. That rock is good for preserving organic remains until it can mature into oil and gas, but it can be exceedingly-difficult to produce from. Fortunately, some oil and gas escapes the source rock and migrates underground. In this module, we discuss how that migration occurs and how migrating oil and gas can accumulate in better-quality "reservoir" rock in trap-like structures. We discuss the characteristics that make good "reservoir" rock and contrast it with the poor characteristics of source rock and tight rock that are the subject of "unconventional" development. We finish with a cool demonstration that shows why rock quality is so important.

Module 7: Oil and Gas Traps

Description: In this module, we explain types of underground features that can "trap" oil and gas. We show animations of how they are formed and how they trap migrating oil and gas. We also show photos of natural features such as anticlines, faults, reefs, deltas and streambeds to demonstrate how these features would be structured underground. An important takeaway from this section is that oil and gas is not found in underground caves or caverns – it's actually within the rock between the pore spaces. We do a demonstration of reservoir rock and seal rock characteristics by putting water drops on the rock so that you can how the water behaves. The water can demonstrate rock characteristics that we can't observe with our eyes!

Module 8: Total Petroleum System

Description: In this module, we bring together all of the petroleum geology elements discussed in prior modules to construct the "big picture" – the Total Petroleum System: source, maturity, migration, reservoir, trap and seal. By this time, you will have a solid understanding of petroleum geology elements and it will all make sense. You will finish this section with a thorough understanding of the difference between conventional traps and unconventional shale and tight rock. We will solidify that explanation with our "girl scout cookies" analogy. When we use that analogy in our live courses, a wave of understanding sweeps over listeners' faces!

Module 10: Risks and Decision Analysis

Description: Exploration is an inherently risky business – you don't know for sure what is in the ground and can drill a dry hole even if a prospect looks beautiful. However, dry holes are only part of the risk, and there are also many things that could turn out better than expected. In this module, we'll discuss key risks and opportunities. Most projects have a range of potential outcomes (rather than just succeed or fail) so we'll take a painless look at how decision trees are used to calculate a statistical "expected value" of a project based on its range of possibilities. We discuss common ways that oil and gas companies mitigate their risks. We finish by discussing all of the factors that have to be considered in choosing an exploration area and you'll come to realize that it is VERY DIFFICULT for an oil and gas company to secure good exploration opportunities!

Module 11: Frontier Exploration Example

Description: This section is both highly informative and entertaining. We examine an actual hydrocarbon-producing basin, discuss how it is structured, and show surface features that provide information about underground rock layers. We hypothetically discuss how geoscientists might choose to evaluate the basin if it was a "frontier" area that had never been explored, and then discuss frontier exploration tools. Although many of these tools employ sophisticated technology, we discuss them in an easy-to-understand way, including satellite imagery, gravity surveys and magnetic surveys. There are also examples of modeling and mapping. There are a few sections where you can choose to explore on your own.

Module 12: Seismic Waves

Description: In this module, we begin our discussion of seismic by describing seismic waves, how they travel, and how they reflect or refract at rock layer boundaries. We use simple, real-world examples that make seismic waves easy to understand and we have a couple of optional drill-down sections for those that want to learn more (P-wave propagation and acoustic impedance). You need a basic understanding of seismic waves in order to understand topics like seismic acquisition, processing and interpretation, which will follow in the next three modules. This section will not only help you understand oil and gas exploration, but it may also interest you to learn about cool natural phenomena that you witness every day and may not have noticed.

Module 13: Seismic Acquisition

Description: In this module, you will learn how seismic waves are created and how seismic reflections are detected. For onshore seismic, you will learn how shot holes and vibroseis trucks are used to generate source waves and how geophones are used to detect reflections. For offshore seismic, you will

learn about seismic vessels and all of the components involved in towed streamer surveys. You will also learn about some of the peculiarities of recording offshore seismic. There will also be brief coverage of ocean-bottom surveys and working in shallow transition zones. There are several optional drill-down sections covering land seismic survey design, geophone design, vertical seismic profiling, micro-seismic and 4-D seismic.

Module 14: Seismic Processing

Description: In this module, you will learn about the useful types of information contained in a recorded seismic wave and how that information is utilized during processing. We discuss how seismic information is convoluted with various types of noise and we discuss techniques such as “common midpoint gathering” that increase the useful signal and reduce the noise. You will see examples of both onshore and offshore raw “shot gathers” and we discuss common steps to get from a shot gather to a useful seismic image. We also discuss how seismic processing is correlated with other available information about an area, such as well logs.

Module 15: Seismic Interpretation

Description: This module presents an interpretation of the major features in an example seismic image. The interpretation involves a discussion of features that an experienced geoscientist could learn just by looking at the image, and how that interpretation can be enhanced by using other knowledge of the area, such as tectonic history and logs from nearby wells. Seismic interpretation can be highly subjective and this exercise will NOT teach you how to become a seismic interpreter. However, all of the information taken together in this course should allow you to follow, with interest, a geoscientist describing a seismic image including the geological background, petroleum system elements, and project economics. The module also discusses “direct hydrocarbon indicators” that are sometimes visible on seismic. The module finishes with a summary of key exploration terms and describes the positions commonly involved in exploration (job titles and duties). There is an optional drill-down that allows you to look at other seismic images highlighting common trap types.