Introduction to Petroleum Geology

An Online Continuing Education Course for Engineers

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INTRODUCTION

Engineering is a profession in which knowledge of mathematics and the natural sciences gained by study, experience and practice is applied with judgment in order to develop ways to utilize economically the materials and forces of nature for the benefit of mankind. Engineers are persons, who by reason of their special knowledge and the use of mathematical, physical and engineering sciences and the principles and methods of engineering analysis and design, acquired by education and experience, are qualified to practice engineering. However, the most useful and simpler perspective is to regard the engineer as a doer and a problem solver, who applies science and technology to solve problems that meet the needs of society. The engineer is in essence an innovator and creator of new products and processes aimed at solving problems in a practical and economic fashion.

The engineer's role is to bridge the gap between an idea and its physical reality by solving problems that exist between the two extremes, very often with little to guide him except for intuition. This we are calling the "creativity gap". The tools of the engineer are the very same scientific principles that have been formulated about the behavior of the universe and its contents. Laws of motion, thermodynamics and matter are among the tools that permit an engineer to fashion a workable solution to a problem. The engineer must develop sufficient depth of understanding of these basic principles so that they, indeed, become useful tools. He/she must be able to devote his/her efforts to building a solution to a problem and not concern himself/herself exclusively with how the tools are to be used.

Petroleum Engineers combine chemistry, physics and geology with engineering methods in the development, recovery and field processing of petroleum. They are concerned with finding deposits of oil and gas in quantities suitable for commercial use through the economic extraction of these materials from the ground. The petroleum engineer will design methods for transporting oil and gas to suitable processing plants or places where they will be used. The function of petroleum engineering is to provide a basis for the design and implementation of techniques to recover commercial quantities of natural petroleum. It is of necessity intertwined with broadly-based technology drawing upon the foundations of engineering, geology, mathematics, physics, chemistry, economics and geo-statistics. As an engineering subject, petroleum engineering is a little anomalous in that design is based on observation of production performance and on a representation of the reservoir inferred from a very limited sampling.

Petroleum engineers are divided into several groups:

- **Petroleum geologists** find hydrocarbons by analyzing subsurface structures with geological and geophysical methods.
- **Petrophysicists** analyze log data after drilling to check the hydrocarbon availability and the rock types.
- **Reservoir engineers** work to optimize production of oil and gas via proper well placement, production levels, and enhanced oil recovery techniques.
- **Drilling engineers** manage the technical aspects of exploratory drilling, production and injection wells. They also include the mud engineer who manages the quality of drilling fluid.
- **Production engineers**, including subsurface engineers, manage the interface between the reservoir and the well, including perforations, sand control, downhole flow control, and downhole monitoring equipment. They evaluate artificial lift methods and also select the surface equipment that separates the produced fluids (oil, gas, and water).

Teamwork is essential because the staggeringly complex nature of a subsurface operation means that the various disciplines have to integrate their specific areas of expertise for the venture to be successful. Some oil companies have separate geology and engineering departments, although this rarely works in practice. Short lines of communication should exist within a subsurface team such that an inclusive atmosphere of shared purpose is created. Any problems that arise can then be quickly recognized and resolved by common directed action (Satteretal.,1994; Neate,1996)

Geologist Functions and Contributions

Geologists play an extremely important role in exploring and discovering natural resources and the mineral wealth of the earth. The main functions of a geologist entail observing natural calamities and their various effects on the environment, and the exploration of mineral, oil and natural gas fields and underwater resources. Their observations of the structure of the earth and the soil is important when evaluating whether conditions in certain areas are suitable for constructing bridges, roads and buildings, or for laying railway tracks.

Furthermore, some geologists also search for deep-sea natural resources. Oil exploration is another field that requires the services of geologists. Geologists can determine the quality of soil by conducting geo-chemical and geo-physical tests. Based on their reports, construction of roads, reservoirs, underground tunnels and bridges can be undertaken. Overall, becoming a geologist involves considerable knowledge and expertise.

Careers in Geology

Geology, as a career choice today, is more exciting than ever before. Whether out on the field as a backpacker, or indoors in the lab, it involves adventure and deep exploration of our planet. The field is wide ranging and offers a plethora of job opportunities. Nevertheless, it is advisable to first find out what kinds of geologist careers are available before you go ahead and make a decision to enter the field.

People studying geology have the option of becoming geographers, geologists, oceanographers or meteorologists. Since geologists play an important role in finding valuable mineral resources, the avenues for them in the private and public sectors are vast. Careers in geology range from studying and predicting natural and man-made disasters to exploring mineral resources. Here are some additional careers that you can pursue if you have a degree in geology:

- Petrology
- Paleontology
- Volcanology
- Geochemistry
- Geophysics
- Mining
- Environmental Education
- Environmental Law
- Environmental Consultant
- Research and Field Study

Petroleum geologists are primarily concerned with determining the location and amount of oil/gas in sediments on land or in the ocean. This job requires one to understand the origin of the hydrocarbon, the amount of oil/gas in the reservoir, the fuel's “maturity” or concentration, the movement of hydrocarbon underground and any obstacles that might impede and not expedite that movement. Petroleum geologists utilize a variety of techniques to discover this information, including geochemical analysis and ground-based sonar to discover reservoirs or satellite mapping. In some cases, petroleum geologists may work side-by-side with oil companies in supervising the oil extraction process.

Generally, the duty of a petroleum geologist is to discover the location and amount of useful fuel in sediments or reservoirs. Geologists in this occupation may be required to interpret geophysical information in project reports, conduct field studies to analyze project data, accurately estimate fuel amounts, interpret and implement drilling strategies for extraction and create post-project reports summarizing the project.

Role of the Petroleum Geologist

Why Geoscience is important in Petroleum Engineering

- Sources of hydrocarbons are in rocks – most of them in sedimentary rocks.
- The hydrocarbon is contained within a pore (void space) or fracture system (or both) within the rocks.
- Depositional processes and the changes that subsequently occur during burial control the geometry of the hydrocarbon-bearing layers in the subsurface.
- Geological maps and cross sections define where the oil is to be found.
- Rock properties define how much hydrocarbon there can be in the ground and how much of it can be economically recovered.
- Wells are drilled through rocks to recover hydrocarbons.
- The minerals that make up the particles of the rocks will influence the distribution of oil and water in a reservoir.

The petroleum geologist works on a subsurface team, a team that manages production for a field and looks for ways of getting more hydrocarbons out of it. He or she has a specific role. The petroleum geologist is responsible for understanding the geological framework of the reservoir and creating a representation of it, typically using computer software. The object of this model is to help understand how geology both influences fluid flow within a producing reservoir and creates dead ends that could potentially trap hydrocarbons. The bigger dead-end pockets may be worth targeting with new wells. If these wells look profitable, the geologist will then take a leading role in planning them along with the drilling engineers.

Petroleum Geologists assigned to an operated field will find themselves working as part of a multi-disciplinary team. In a large company, this will include a subsurface manager, geologists, geophysicists, petro physicists, reservoir engineers, production engineers, chemists, and technical assistants. Some teams may also include drilling engineers and economists.

Overview of Geology and the Earth's History

In the very beginning of earth's history, this planet was a giant, red hot, roiling, boiling sea of molten rock - a magma ocean. This heat had been generated by the repeated high speed collisions of much smaller bodies of space rocks that continually clumped together as they collided to form this planet. As the collisions tapered off, the earth began to cool; it formed a thin crust on its surface. As the cooling continued, water vapor began to escape and condense in the earth's early atmosphere. Clouds formed and storms raged, raining more and more water down on the primitive earth, cooling the surface further until it was flooded with water, forming the seas.

It is theorized that the true age of the earth is about 4.6 billion years old, formed at about the same time as the rest of our solar system. The oldest rocks geologists have been able to find are

3.9 billion years old. Using radiometric dating methods to determine the age of rocks means that scientists have to rely on when the rock was initially formed when its internal minerals first cooled). In the infancy of our home planet, the entire earth was molten rock - a magma ocean.

Since we can only measure as far back in time as we had solid rock on this planet, we are limited in how we can measure the real age of the earth. Due to the forces of plate tectonics, our planet is also a very dynamic one; new mountains are forming, old ones are wearing down, volcanoes are melting and reshaping new crust. The continual changing and reshaping of the earth's surface that involves the melting down and reconstructing of old rock has pretty much eliminated most of the original rocks that came with earth when it was newly formed. So it is a theoretical age.

A geologist is someone who studies the earth's composition, mainly the different kinds of rock formations. It also involves the study of organisms that inhabit it. The science deals with the analysis of the earth and its origin, history, and minerals. Some of the branches of Geology are Mineralogy, Geological Engineering and Geomorphology, to name a few.

Geology Basics

A knowledge of the earth's interior is essential for understanding plate tectonics. A good analogy for teaching about the earth's interior is a piece of fruit with a large pit such as a peach or a plum. Most of us are familiar with these fruits and have seen them cut in half. In addition, the sizes of the features are very similar.

If we cut a piece of fruit in half, we will see that it is composed of three parts: 1) a very thin skin, 2) a seed of significant size located in the center, and 3) most of the mass of the fruit is contained within the flesh. Cutting the earth, we would see: 1) a very thin crust on the outside, 2) a core of significant size in the center, and 3) most of the mass contained in the mantle.

The structure of the interior of the earth has been investigated by refraction seismology. Shock waves from earthquakes and nuclear explosions can be detected at various points around the globe, and their arrival times are used to determine the depths of major density changes within the earth. These studies suggest that the earth's interior can be divided into 3 main layers: the core, mantle and crust. The broad chemical composition of these layers is determined by comparison with rocky meteorites that have landed on the earth's surface.

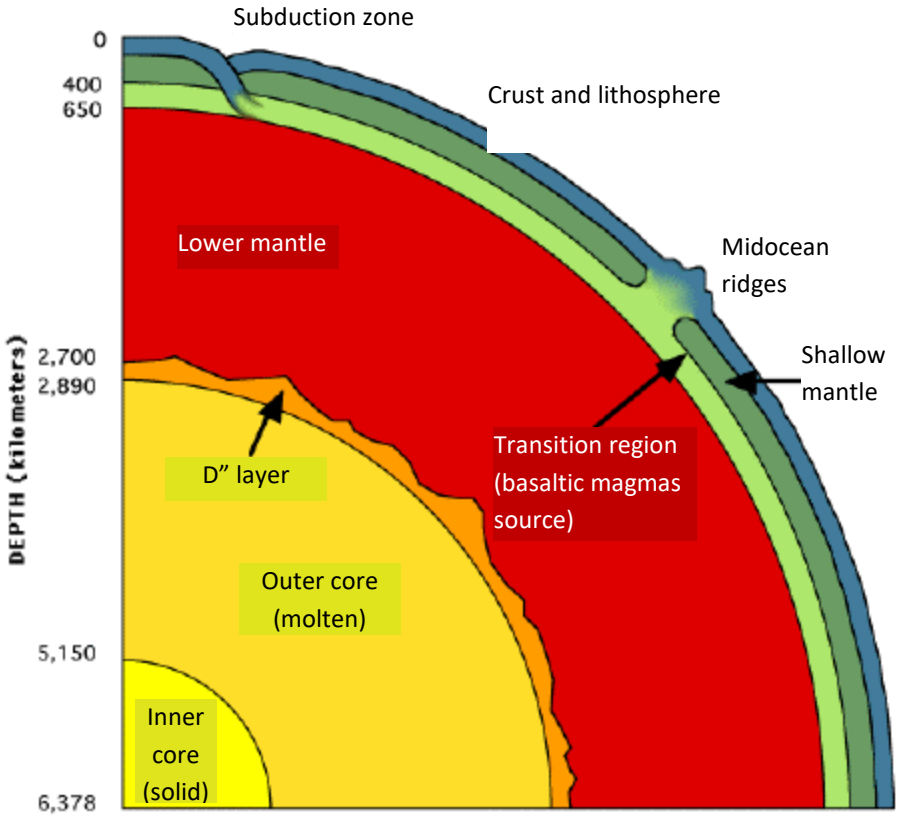

Figure 1: Three Layers Earth's Interior: core, mantle and crust

The crust is the layer that is of most imp… Geologists distinguish between oceanic crus… e oceans and is thick-- about 5-7 miles (8-11… is formed when molten rock (magma) cools. C… 48 km--and is composed of rock that is relativel…