Lecture-1

General Introduction:

In addition to the Internet revolution, specific technology advances over the past few years include improved seismic processing and imaging for 3D and 4D seismic surveys, drilling in deeper offshore waters and onshore horizontal drilling and completions, and continued understanding of the physiochemical makeup of reservoirs at finer-and-finer detail.

Extraction of oil and gas from shale and tight sands has revolutionized the global energy balance and the petroleum industry's response to that revolution. Although it has long been recognized that there is an abundance of oil and gas in shale.

Advances in horizontal drilling, artificial fracturing (required of almost all sales to make them productive), and passive seismic monitoring provided the capability to economically extract oil and gas from these ultra tight rocks.

Engineering and geophysical advancements, coupled with higher resolution computing capabilities, have led to steady improvements in our capacity to build quantitative 3D geologic models for reservoir performance simulation and volumetric calculations.

"The shale/tight sand reservoir play changed the concept of a hydrocarbon reservoir forever and the key to the evolution of our knowledge and understanding of this incredible play is reservoir characterization, the collaboration of geology, geophysics, and engineering."

Integrating Expertise for Reservoir Characterization:

Today, the field of reservoir characterization routinely involves disciplines of geology, geophysics, petrophysics, petroleum engineering, geochemistry, biostratigraphy, geostatistics, and computer science. "The principal goal of reservoir characterization is to outsmart nature to obtain higher recoveries with fewer wells in better positions at minimum cost through optimization."

Unconventional Resources in the Hydrocarbon Industry:

The Shale Gale and Gas Hydrates are one of many unconventional resources in the hydrocarbon industry. Shale Gale is now considered an important source of energy worldwide , currently accounts for 33% of U.S. natural gas production, and by 2035, it is predicted to account for 60% (HIS Global Insight, referenced in Ramchand, 2012).

Globally, such countries as Argentina, Australia, Canada, China, Colombia, India, Poland, and Saudi Arabia are currently active in shale gas exploration.

Another unconventional resource with tremendous potential is gas hydrate. Gas hydrate is a naturally occurring, “ice like,” solid combination of natural gas and water with a crystalline structure of a hydrocarbon molecule (usually methane; CH4) surrounded by a cage of water molecules.

Seismic reflection surveys are the principle means by which gas hydrate deposits have been discovered and mapped offshore. The major constraints to production are both technical and economic.

3D seismic technology can image fine-scale stratigraphic and structural features that were previously unnoticed by mapping from well control but were highlighted after application of seismic attributes. Horizontal drilling is now widely used to improve recovery over a larger area of a reservoir, either in highly compartmentalized reservoirs or in blanket-type deposits Thus, the characterization of reservoirs has evolved from a simple engineering evaluation to one developed by multidisciplinary teams of geologists, geophysicists, petrophysicists, and petroleum engineers.

Brown Fields:

Reservoir characterization is particularly applicable to “brown fields.” This is a relatively new term in the oil industry, which is synonymous with “old field,” “mature field,” and “marginal field” (Hassam, 2008). Brown fields are fields that have passed their peak production and are now on significant production and economic decline. Some companies restrict the term brown field to those fields that have been on production for >30 years. About 60% of the world’s oil production comes from brown fields. Operating companies try to extend the economic life of the field by cost-effective, low-risk technologies such as stimulation, refactoring, completing additional zones, infill drilling, use of artificial lift, and reinterpreting old data, such as well logs and well tests (Schlumberger, 2012). Because the infrastructure is already in place, such fields can be made to be economic with only an incremental increase in production. A problem associated with characterizing a brown field is that over time, field data have been lost or destroyed and such data sets as well logs are old and not readily amenable to advanced characterization. In such cases, it is wise to drill a new well for calibration of the wellbore geology with the older well data.

Compartmentalization Of Oil And Gas Reservoirs:

Integration of technical disciplines over the past few decades has changed our perception of the characteristics of oil and gas reservoirs. Whereas it used to be commonly perceived that oil and gas reservoirs were relatively simple geologic features, the reality is that they are quite complex and they can be sub-divided into architectural elements or compartments on the basis of several structural and stratigraphic features Part of the misconception comes from the fact that one cannot actually see a reservoir, because it is beneath ground level. Thus, in the initial through final stages of characterization, investigators should assume that the field will be compartmentalized and segmented, even at scales too small to recognize by normal between-well, subsurface technologies.

Scales and Styles of Geologic Reservoir Heterogeneity:

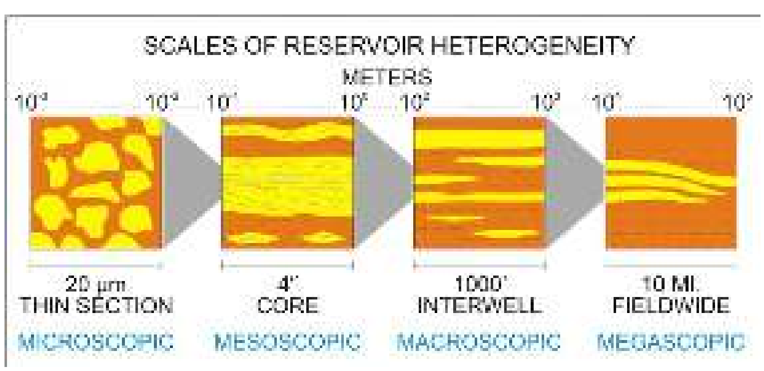
A variety of types and scales of heterogeneity are found in most reservoirs. Classifies heterogeneities according to scale. From the smallest to the largest scale, they are microscopic, mesoscopic, macroscopic, and megascopic heterogeneities.

<u>Microscopic</u> or pore/grain-scale heterogeneities are related to pores and arrangement of grains, including pore volume (porosity), pore sizes and shapes, grain-to-grain contacts that control permeability, and grain types.

<u>Mesoscopic</u> or well-scale heterogeneities can be recognized in the vertical dimension, such as in cores or well logs. Such heterogeneities include bedding and lithologic types, stratification styles, and the nature of bedding contacts.

<u>Macroscopic</u> or interwell-scale heterogeneities occur at the scale of well spacing. Such heterogeneities include lateral bed continuity or discontinuity as a result of stratigraphic pinch-out , erosional cutout, or faulting.

<u>Megascopic</u> or field-wide heterogeneities, such as overall geometry and large-scale reservoir architecture (related to structure and/or depositional environment), normally can be delineated by 2D or 3D seismic, well tests, production information, and field-wide well log correlation.



Hen Is Reservoir Characterization Important In The Life Cycle Of A Field?
The Life Cycle of a Field:

Figure 1.32 shows the phases of an oil or gas field's life cycle. Initially, mapping and reconnaissance are conducted by exploration geologists and geophysicists. They gather data from outcrops, old wells, seismic, and any other information that is available, and they use it to develop a regional understanding of the area's geology. Of prime concern at this stage are the structure of the basin and the sub regional features (i.e., are there fault and/or fold traps for hydrocarbons?), the stratigraphy (are there reservoir rocks with porosity and permeability, and are there organic shale that can generate hydrocarbons in the basin? Are there shale seals?), and the burial history of the basin (have the source rocks been buried sufficiently for hydrocarbon generation, and have the reservoir rocks been cemented during burial?).

Applying Reservoir Characterization:

Thus, with all of these activities, when is reservoir characterization most important? Many professionals will answer this question by stating that characterization begins as soon as the discovery is made and the first data become available (usually from seismic and the discovery well and perhaps from earlier dry holes in the area).

The goal of many reservoir characterization studies is to provide a 2D or 3D geologic model to petroleum engineers for reservoir performance simulation, for performance prediction, and for well planning. The stages of model building are shown in Fig. below and include defining the regional-to-local geologic structure and stratigraphy and then more localized layer boundaries, filling the volume between the boundaries with strata, and gridding the model and inputting numerical values of reservoir parameters into the grid blocks.