IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 5, Issue 6 Ver. I (Nov. – Dec. 2017), PP 54-58
www.iosrjournals.org

Advances in the Investigation on Behavior of Carbonate Reservoir Rocks

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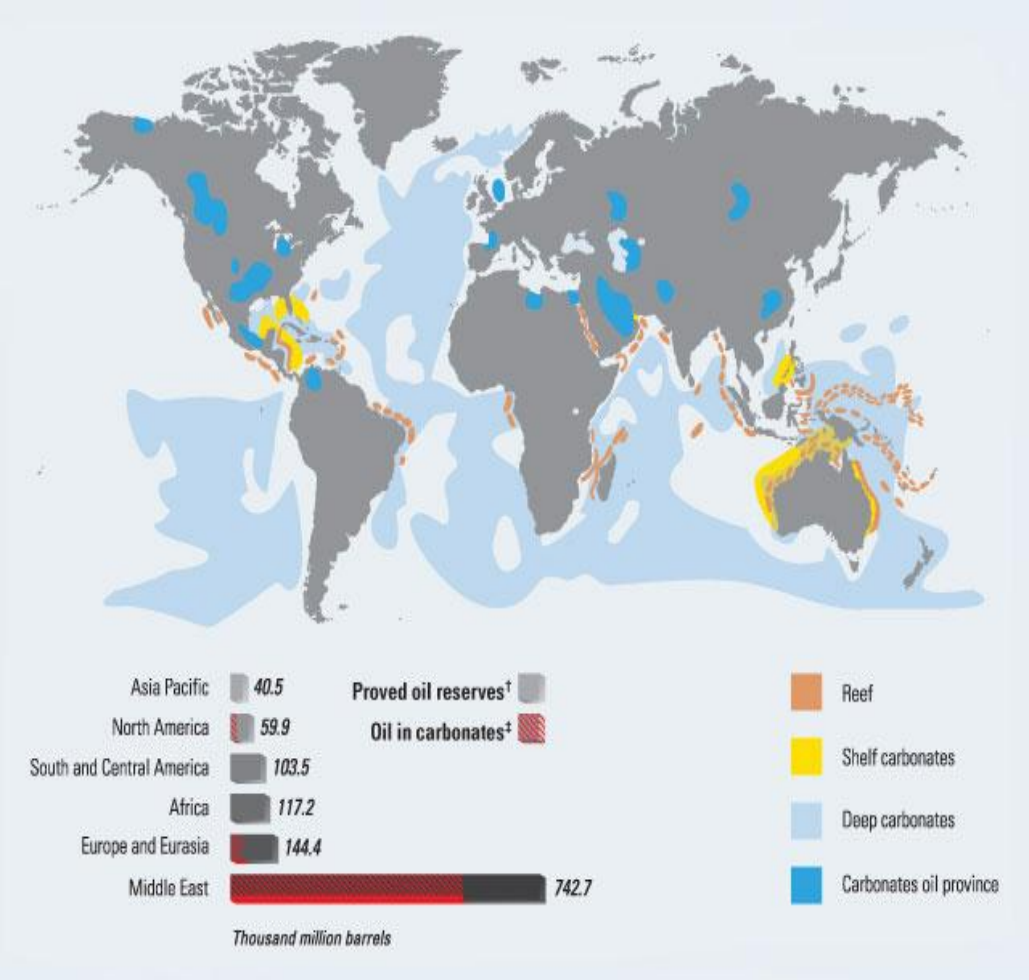
Abstract: *Carbonate reservoirsbeing the main carriers of oil with a great deal of natural gas found in the past five years.Carbonate Reservoirs contribute to more than half of the World's Conventional Petroleum Reserves. The characteristics of carbonates make the Hydrocarbon exploration and production a complex.Rock Heterogeneityvaries at all scales and properties (porosity, permeability and flow mechanisms).The application of innovative techniques for the new plays in carbonate rocks epitomizes frontier exploration. The permeability is controlled by fractures and faults in most of the low-matrix-porosity hydrocarbon reservoirs that are productive. Geological risk can be reduced by understanding the reservoir basic fractures and faults which in turn reduces the well costs and increasing the hydrocarbon recovery. Investigation for the long-standing recognition of naturally fractured carbonate reservoirs is needed to evaluate the new fracture and fault analysis is important for the prediction techniques and understanding of the concepts of carbonate reservoirs with low matrix porosity. Fractures and diagenesis are particularly essential in carbonate reservoirs for the related challenges of geomechanics and mechanical stratigraphy will become increasingly important. With the application of new techniques and concepts to investigate carbonate reservoir rocks continues to build through the successful production of hydrocarbon oil & gas in ultra-deep carbonate reservoir targets and diagenetically and geomechanically complex resource plays in carbonate rocks.*

Keywords: *Carbonate reservoir, Hydrocarbon exploration, rock heterogeneity, geological risk, low matrix porosity.*

Date of Submission: 01-01-2018 Date of acceptance: 11-01-2018

I. Introduction

The intrabasinal origin of carbonate reservoir rocks make them distinctive and unique among the reservoir rocks more over their constituents are primarilyderived from organic activities for their susceptibility to modify by post-depositional mechanisms features significant to distinguish the productivity of carbonate reservoir rocks from other reservoir rocks which includes sandstone and shale. Primary reservoir properties like porosity, permeability & flow mechanisms vary highly within the carbonate reservoir rocks is difficult to characterize. Carbonate reservoirs contribute more than 60% of the world's Oil and 40 % Gas reserves .One of the major challenges in E& P industry, the activities is performed without deep knowledge in physics behind the formationis facingmany problems in drilling carbonate. Rock mechanics play a vital role in E & P operations in a carbonate reservoir. This investigation presents an overview of some developments and some new technical opportunities and aiming for high productivity demands engineering to maximize thevalue. In going deeper geological complexities and mechanization demandbetter integration of engineering to ensure ease of drilling. The understanding of physics with high quality experimental data can be obtained to understand the predictability to improve control over carbonate reservoirs and overcome the problems with the carbonate reservoir formation.



World Distribution of Carbonate Reservoirs

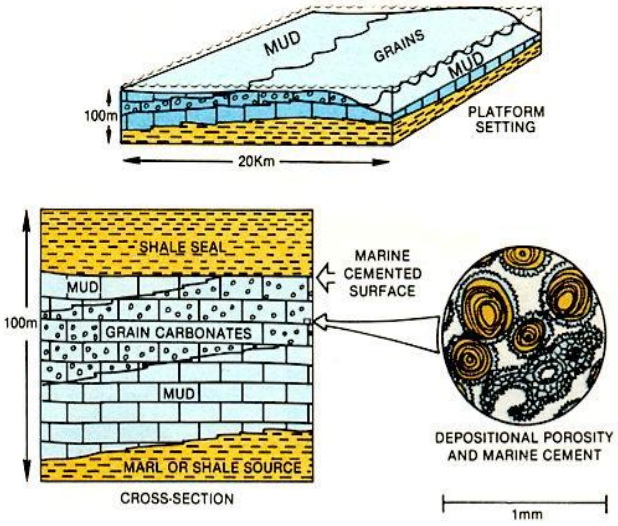
The most complex reservoir in existence are the carbonate reservoirs with complexity and unpredictability of carbonates made engineers and scientists in a difficulty for predicting the recoverable Oil & Gas from that particular reservoir.The importance of fractures, Vugs and faults is considered to be very important for the permeability versus porosity behavior.Avery wide range of drilling conditions are experienced by the drillers in the carbonate formations as carbonate rocks vary from very soft formation to extremely hard rocks, and there are often drilling fluid losses which are often massive and unpredictable. The question form the common factor observations of carbonates are unpredictable.

Carbonates

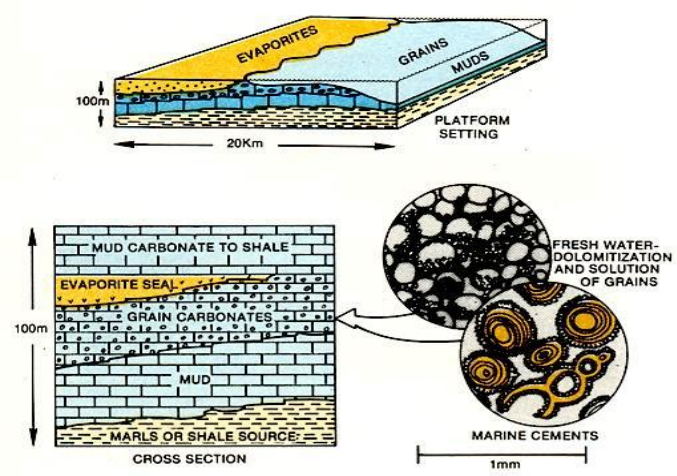
Carbonate Reservoir:

Carbonates are formed in special environments and they are biochemical in origin. Organisms play an important role and have direct role in determining the reservoir quality. Processes like compaction; lithification and other diagenetic events result in large variations in the reservoir quality of carbonates. Reservoir characterization issues, including the geological framework, rock fabric, facies, and porosity and permeability distributions, are some of the most widely investigated production issues today. Many challenges exist in characterizing, quantifying, and predicting carbonate reservoir quality. The key to understanding carbonate reservoirs is recognizing the critical link between geological heterogeneity and reservoir quality and performance. Finding the link between geological heterogeneity and reservoir quality often becomes a matter of finding the appropriate data and sampling the heterogeneity at the appropriate scale. The arrangement and distribution of the mineral as well as organic components in carbonate reservoirresulting in various bedding and layering features are controlled basically by deposition and sedimentation. These features are characterized by their texture and structure. This includes variations in composition, size, shape and orientation of the particles and components, and in their packing. The significance of the research on rock mechanics indicate in the effect of distribution of the initial stress on carbonate reservoir rocks can be evaluated. The essential of the failure for rock strength is to be analyzed based on the situations of the drilling.

There are diverse property and peculiarity for the stabilization of the rock mechanics in the carbonate reservoirs which are to be interpreted in this project work.



The primary porosity of carbonate reservoir is preserved (above figure) as carbonatesands get terminated by burial beneath deeper water sediments Similarly primary porosity will likely be preserved in carbonatesands terminated by the deposition of evaporites (figure below). The sealed Carbonate reservoir does not allow the movement of fresh water through the overlying strata and the sands are protected from diagenesis.



Dolomitization(above figure) occur when regional fresh groundwater system is confined beneath the seal. Carbonate muds or shales are the possible source rocks where the seal could be updip progradational shales, evaporites or offshore marine shales deposited during a subsequent sea level rise.
Carbonate reservoir rocks is chosen to study the correlation between rock fabrics and physical properties of reservoir rocks. Detailed fabric analyses and texture investigations is to be carried out as well as laboratory measurements of different physical properties, e.g. density, porosity, permeability, electrical conductivity, seismic compression and shear wave velocities. We can interpret the great differences in the occurrence and three-dimensional distribution of the rock fabric elements. These heterogeneities are the result of various diagenetic and tectonic processes.Major constituents,e.g.fossils, ooides,peloides and crystals, Pore space with different pore types ,Fractures and Stylolites are considered to be the four main rock fabric types to correlate between rock fabrics and the physical properties.The anisotropies of the petrophysical properties are found by correlation which is related to the observed fabric elements, with their different arrangements, spatial distributions and preferred orientations.These results also provide a fundamental understanding of the petrophysical responses, such as seismics, to the different geological features (e.g. fractures) and their dynamic changes with pressure, which can be converted to different depths. The knowledge gained from such correlations may lead to an improved interpretation of geophysical data for hydrocarbon exploration and production and therefore to an advanced reservoir characterization.

Dynamic geomechanical models are of significant value for carbonates due to the elastic nature and susceptibility of carbonate to in-situ stress changes. Production of fluids results in pore pressure changes may contribute to alternation of reservoir rock properties. Permeability is lightly dependent on the in-situ state of stress. Secondary permeability generated by small fractures can havea impact on the effectiveness of fluid injection and production. Mobility of fluids is much higher in the direction of maximum horizontal principal stress. Natural fractures trending in the direction of maximum horizontal principal stress are more permeable as they often remain open, whereas fractures perpendicular to the maximum horizontal principal stress are generally sealed. The challenge is the evaluation of the stress state (both magnitude and orientation) and the rock strength.

As on date research in the field of rockmechanics oncarbonate rocks is going on both at national and international level but still the result is not satisfactory due to lack of knowledge in the physics behind the carbonate reservoir rocks. Since the Oil & Gas industry is booming one, the operationsperformed bythe Industry is at high rate (Eg: the per day cost for Offshore rig is 45,000 USD) this example shows the operation performed at high risk and high cost. This will give the fruitful result for cost reduction to perform operations. This study however further shown that changes from the natural fractures to complex vugs overtime as the reservoir ages and the production years increases. Hence the production engineers must adopt production and recovery techniques that will preserve the natural fractures that were formed during deposition and sedimentation period of the reservoir.

II. Conclusion

Carbonate reservoirs originated in different depositional environments, lithofication and diagenesis results in different range of carbonate rock classes with significant oil and gas in carbonate reservoirs in the world. These complex processes provide multifaceted pore systems, complicated interconnectivity and reservoir quality. Understanding the behavior of rock mechanics in subsurface is premier challengeable one .It plays a vital role in oil & gas industry in every field(well engineering , reservoir engineering , production engineering).Lack of research in rock mechanics is the main cause for uncertainties in oil & gas operations.It is important to have a detail understanding regarding the fundamental controls on carbonate porosity and permeability evolution, the prediction of reservoir quality using geophysical data and upscaling of porosity, permeability, and the physics of multiphase flow. Perform Rock Mechanics tests on carbonate rocks of increasing solid framework complexity.

Derive predictive relationships for carbonate rock type and for deformation type.Generalgeomechanicalnumerical formulations that replicate experiments and extend them to subsurface reservoir scenarios and also develop link between experimentally-generated data and geomechaniccalculations and derive potential rock damage (e.g. distribute into fracture patterns, shear bands, compaction bands) from the numerical results.

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IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) is UGC approved Journal with Sl. No. 5021, Journal no. 49115.

Dr.T.Nagalakshmi. "Advances in the Investigation on Behavior of Carbonate Reservoir Rocks." IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) , vol. 05 no. 6, 2017, pp. 54-58.