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Petrophysical Properties of Reservoirs and Seal Characteristicsat Ataga Oil Field, Niger Delta

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Abstract:

Several studies has been performed on modelling petrophysical properties of reservoirs in the Niger Delta region, this study consider the use of PetroMod. Seal characteristics had been included to emphasize its significance in prospect evaluation. In this study the reservoir porosity was derived to range 20.45% and 23.18%, and permeability in the range of155md and 355md. The seal characteristics derived are 2x10 ¯3md, 13.4% and 11.82% for permeability and porosity. The pore pressures were 71.79% and 69.34% of the Lithostatic pressure, while the retention capacities are 12.73 MPa and 16.55MPa for the reservoirs. The characteristics derived indicate that the reservoir are none overpressured for which there is no leaky tendency for the seal/caprock.

***Keywords* —Caprock, Niger Delta, Permeability, Porosity, Pore Pressure,Retention Capacities.**

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I. INTRODUCTION

The petroleum system elements which consist the seal, source rock, reservoirs and traps principally determines the potential of a petroleum system, however, the processes also play a complementary part to prove the functionality of the elements [15]. The reservoirs serves as storage facility for the accumulating petroleum. The efficiency of the reservoir can be delineated from the porosity (storage) and permeability (transmissibility) of the reservoir sandbody. The seal/caprock principally preserves the accumulated petroleum from leakage to upper series/prospects above the reservoir and exposure to alteration (biodegradation).

The reservoir pore pressure is also vital to preservation of hydrocarbon, if the pore pressure is high the potential for capillary and hydraulic/fracture leakage reaches a higher probability. The Niger Delta is principally characterized by overpressure Akata Formation, due to ineffective dewatering of the formation during compaction, resulting from higher rate of deposition relative to the rate of subsidence/burial [9].The effectiveness of a caprock can be measured based on their petrophysical properties, such as permeability, porosity, pore pressure relative to the fracture pressure and the retention capacities.The possible lithostatic pressure is in the range of 22.4MPa/km, while the hydrostatic pressure may range up to 10.9 MPa/km [15].Caprocks for which their corresponding reservoir pore pressureis greater than 80% of the lithostatic pressure are proneto fracture leakage, which occurs when the pore pressure is greater than the tensile strength of the caprock. Capillary leakage is a function of the buoyant pressure, which must overcome the resistance of the rock matrix against fluid flow.

The study of reservoir and caprock properties has assumed higher dimension, which has to do with modelling. Modelling, principally depends on the accuracy of the input data, which should be precise. In this study, petrophysical and seal/caprock properties were derived from a model used in [10].

The study is based on the hypothesis that software such as PetroMod can be used for the derivation of correct petrophysical parameters such as porosity, permeability, pore pressure, fracture pressure and effective stress etc.

II.METHODS AND MATERIALS

The data for this study is same as that used in [10],well logs were used to derive TOC and S2 employing Techlog Version 2015.Geological data such as formation data (deposition, erosion, age and facies), lithological data, petroleum system elements data, were obtained from well completion reports. Geochemical data such TOC and Hydrogen Index were obtained from well logs and the appropriate kinetics inputs and boundary conditions were obtained from literature [10]. 1D package of PetroMod version 12 was employed in generating depth plots for relevant petrophysical parameters and seal/caprock characteristics.

III. RESULTS AND DISCUSSIONS

The results derived from the model, were extracted as depth plots.

A. Porosity and permeability of Caprocks and Reservoirs

The porosity describes the void space available within the matrix of the rock for storage of oil. The porosity of the reservoir at 3.1km is 23.18% while that of the second reservoir at 3.6km is 20.45% as in figure 1. Qualitatively, these are high porosity reservoirs [3], [4]. The permeability of the reservoir section at 3.1kmis 2.55log(md) [355md] and 2.18log(md) [156md] for reservoir at 3.6km. Several studies on the petrophysical properties of Niger Delta Oil fields reservoirs has placed reservoir porosities in the range of 20–35% and may be more, and permeability had be estimated for Niger Delta reservoirs ranging in values from 178md – 1000md and above [11],[12],[13],[14].Relative to the values in previous studies, it could be agreed that the derived values for the reservoirs at the Ataga Field is representative of a reservoir in the Niger Delta. Qualitatively, the values derived from the model represents a moderate flow rate on a graduation scale.

The permeability value for the seal/caprock derived is -3.64log(md) [2x10 $^{-}$3md] at both 2.76km and 3.41km,caprocks have been recorded to have lower values [5],[15].The porosity values are 13.4% and 11.82% at both depths respectively.Most of the reservoirs in the Niger Delta are in the Agbada Formation, the formation has a descriptive lithology that consist of mostly sandstone and sandbodies with shale layers. The shale intercalations are described as shaly at the based but become sandy and silty upwards grading into overlying sand and sandstone bodies [16]. This may explain the fair porosities for a seal/caprock in the Niger Delta. The reservoirs are mostly sealed by the shaly intercalations. Studies on caprock porosity and permeability on samples from USA and Oman has placed caprock porosities in the range of 3.9% to 22.4% [6].

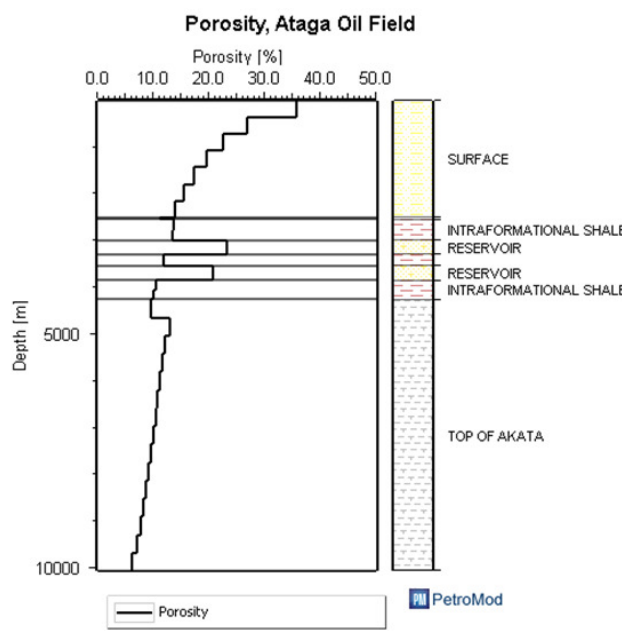

Figure 1. Porosity Depth plot for Ataga Oil Field Area

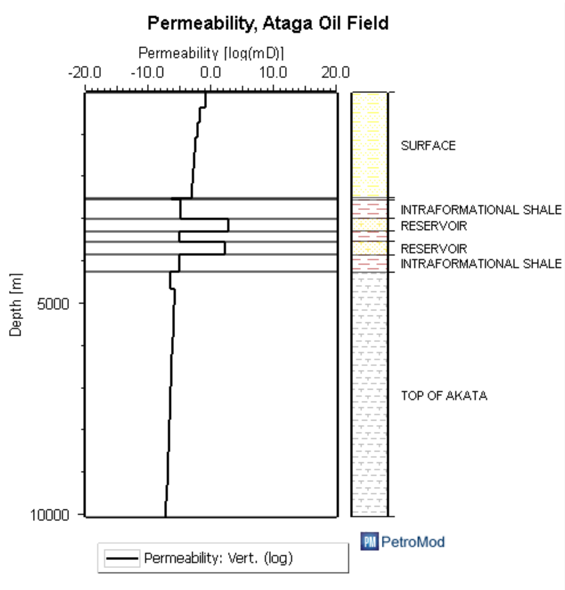

Figure 2. Permeability depth plot for Ataga Oil Field Area.

The porosities values obtained in this study corroborates with those derived from other studies. The Niger Delta is not a tectonically active zone, thus tectonically induced fracture may not drive leakage from reservoirs, but is pressure driven since it is an overpressure zone. Overpressure may foster capillary leakage and hydraulic leakage. Reservoirs in Agbada Formation may not be overpressured, in such case capillary leakage via the pores of the caprock matrix could be fostered by the buoyant pressure.

B. Pore Pressure of Reservoirs.

The pore pressure is the formation pressure driven by the formation fluids. The pore pressure normally increases with depth.The pore pressures of the reservoirs are 50.91MPa at 3.12km and 58MPa at 3.68km (figure 3). The fracture pressure is the pressure at which the reservoir fluid will breach the caprock via hydraulic fracture. The fracture pressure for the reservoir at 3.12km is 63.64 MPa, while that of the reservoir at 3.63km is 74.55MPa.

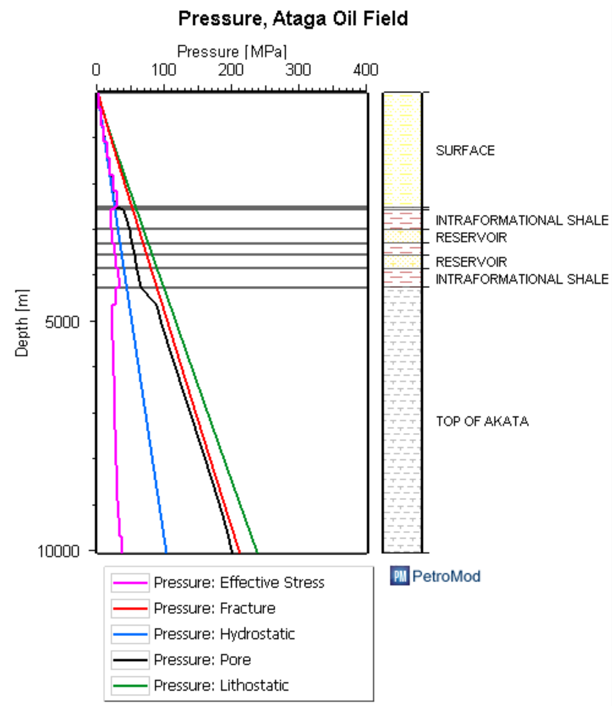

Figure 3. Pressure–Depth profiles

The lithostatic pressures are 70.91MPa and 83.64MPa respectively. Where the pore pressure is up to 80% of the lithostatic pressure, it can be implied that the caprock will leak, in this study the pore pressure are derived to be 71.79% and 69.34% at 3.12km and 3.63km respectively of the lithostatic pressure, this implies that the caprocks are not leaky and the reservoir are not overpressured [1],[2]. This concept actually influences prospect risking in overpressure region as in Niger Delta Basin.

C. Retention Capacities and leaking possibilities

The retention capacities had be related to exploration risk at high pressure regions. [1], in a study related retention capacities lower than 6.8MPa to caprocks that were leaking.

Retention capacity is the difference between the fracture pressure and the pore pressure, it represents a measure of the pore pressure increase, a trap can tolerate before the seals fails. In this study the retention capacities for the reservoirs are 12.73 MPa and 16.55MPa (figure 3), these values are significantly higher than the threshold value of 6.8MPa. Retention capacity values lower than 6.8MPa has been associated with leaky caprock in the North Sea.

IV. CONCLUSIONS

The model for [10] was used to derive petrophysical properties which basically are the porosity and permeability of the reservoirs and the seal characteristics of the caprock. The porosities of the reservoirs were derived to be 20.45% and 23.18%, these values qualitativelyrepresent moderately high porosity. The permeability of the reservoirs are in the range of 155md and 355md. The reservoir pore pressure ranges from 50.91MPa to 58MPa, however, the range is far below the fracture pressures which are 64.64MPa and 74.55MPafor the both reservoirs respectively. The retention capacities are 12.73MPa and 16.55MPa, these values are far above the threshold value of 6.8MPa which is largely associated with leakage. Invariably, this implies that the seal/caprock at the Ataga Oil Field area hashigh integrity for holding back petroleum in the reservoir from leaking.

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