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A STUDY ON EVOLUTION OF POROSITY IN SANDSTONE RESERVOIRS OF OKHMINTAUNG FORMATION BETWEEN NGAPE AND YENAMA AREA, MAGWAY REGION

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Abstract

The area under investigation lies in Ngape Township, western part of Minbu, Magway Region. In the study area, the Cretaceous to Pliocene Formations are exposed. The main structure of the study area is monocline. The present research aimed to conduct reservoir potential of Okhmintaung Formation. Stratigraphically, the Okhmintaung Formation (Late Oligocene) is mainly made up of thin- to medium-bedded sandstone with bluish gray shale. Petrographically, the sandstone of Okhmintaung Formation is arkose and lithic arkose.By the facies analysis, in Okhmintaung Formation, from top to bottom, Thick- bedded to massive sandstone facies, sand with gypsum intercalation facies, bioturbated sandstone facies, nodular gray shale facies, and sand-shale alternation facies were observed. By the petrographic texture, porosity, and diagenetic features enhancing or destroying the potential porosity of the sand body are also started in Okhmintaung Formation. Some of the sand bodies do not favor the potential of good reservoir because of the size, textural features and diagenetic imprints. Some of the reservoir cannot regard as medium potential due to the petrographic fabric forming lesser potential. By studying the diagenetic features, some of the Okhmintaung sandstone possesses pore-filling clays and very thin grain coating. These authigenesis can destroy reservoir potential and cannot regard as medium potential due to the petrographic fabric forming lesser potential. The textural features suggest that Okhmintaung sandstones are fair reservoir.

Keywords: Porosity, Permeability, reservoir potential, authigenic mineral.

Introduction

The area is located between latitudes 19°46′00″N to 20°04′00″ N, and longitudes 94°25′00″ E to 94°40′00″ E, covering approximately 9.3 miles (15km) in width and 24.8 miles (40 km) in length. It is situated in the western flank of Salin syncline and also situated between Padan to the south and Yenanma to the north, Figure (1). There are two major streams which generally flow from west to east and locally named Mann Chaung in the northern part and Sabwet Chaung in the southern part. These streams flow into the Ayeyarwaddy River. Generally, pattern of the main streams and its tributaries are mainly developed parallel to the regional strike, and tectonic structure such as faults and fractures. The topography of the eastern region is characterized by flat lying and the mountainous rugged terrains in the western margin, trending NNW-SSE direction.

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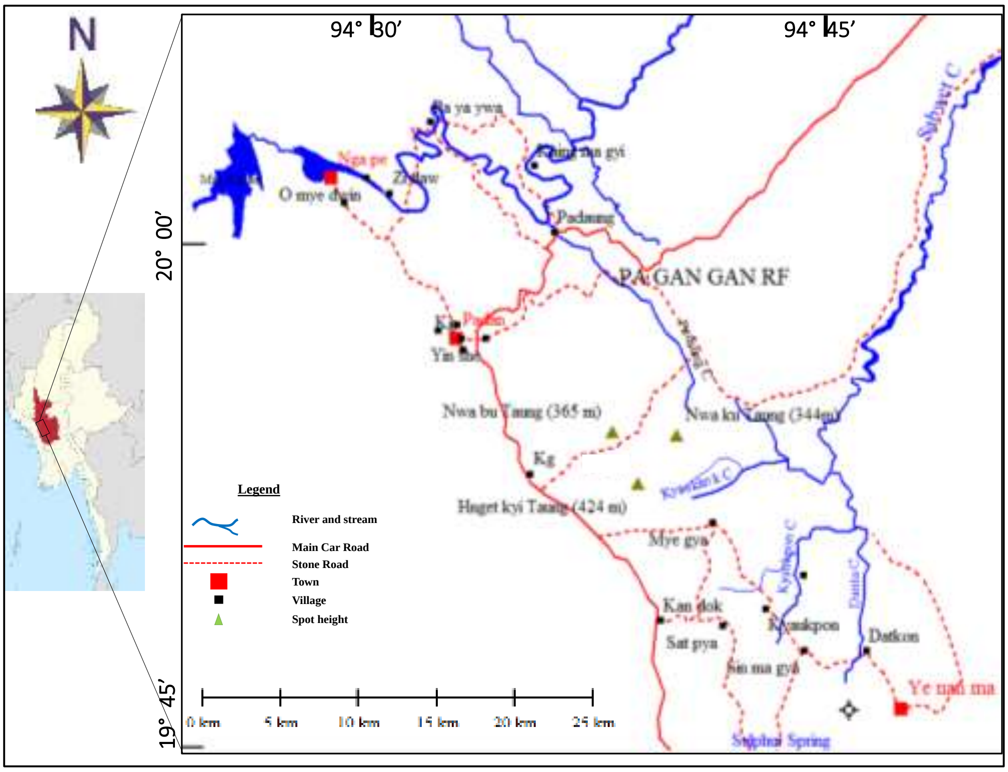


Figure 1 Location map of the study area

Regional Geologic Setting

The study area consists of the following formations and the litostratigraphic correlation. This research mainly focused on the Oligocene Formations such as Shawezetaw Formation, Padaung Formation, and Okhmintaung Formation.

The general structural trends of the study area is NNW-SSE in direction. Attitude of the rock unit of the Shwezettaw Formation is about (45°) with NE dipping. The rock unit of Padaung Formation is about (30°) attitude and (45°) direction. The attitude of the rock unit of Okhmintaung Formation is average in (30°/050°). All of the beds of formations are nearly NE in directions.

Major fold is a broad monoclinal syncline. Present study area is the western part of Salin Syncline. In the western part of the study area, steep dips towards the east in dip amount of 45° to 60°. In the eastern part of the study area, become gradually shallow to the east towards the Minbu syncline, 20° to 15°. In the southern part of the study area, dip amount of the monocline gradually decrease from 30° to 10°. Monocline is cut-cross by a series of E-W trending cross faults, more abundant in distribution and longer in length to the south of the study area.

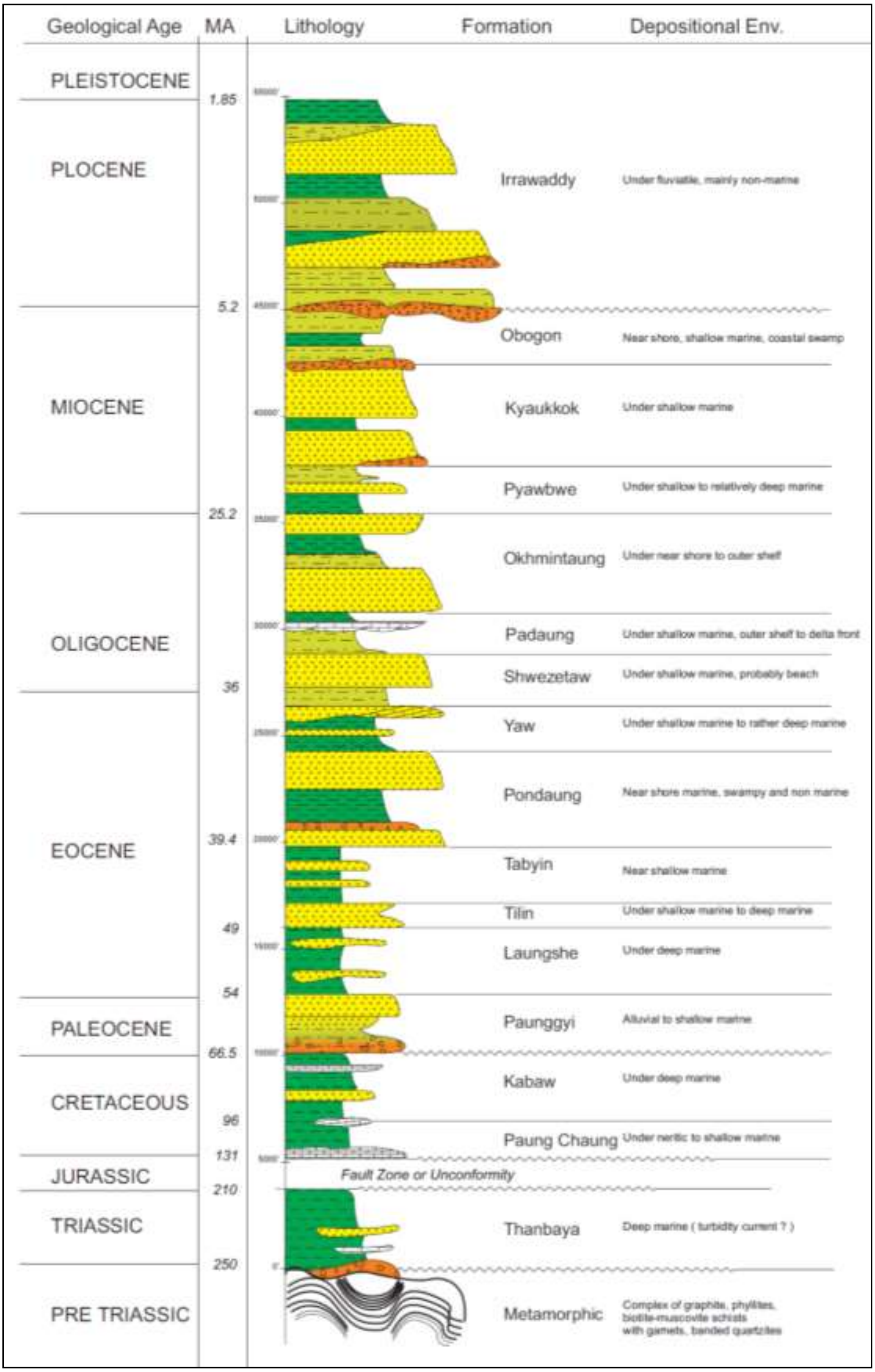


Figure 2 Regional stratigraphic succession of the Minbu Basin (Than Htut, 2008)

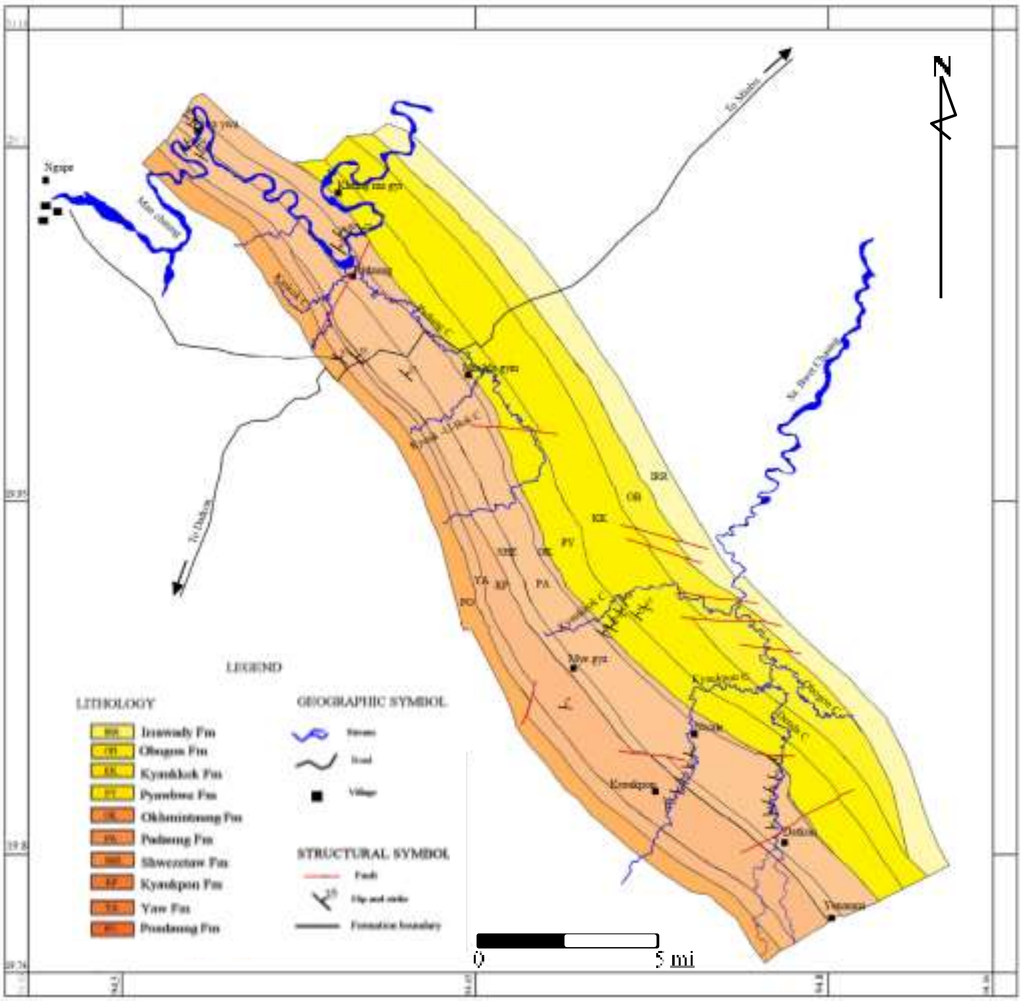


Figure 3 Geological map of the study area (Based on M.O.C, 1982)

Effect of Texture on Sandstone Reservoir of Okhmintaung Formation

Relationship between porosity, permeability, and grain shape

The grain shape of Okhmintaung sandstones are angular to sub-angular with sub sphericity. Figure (4). Fraser (1935) inferred that porosity might decrease with sphericity because spherical grains may be more tightly packed than subspherical ones.

Relationship between porosity, permeability, and grain size

Okhmintaung sandstones mainly comprise average on 60% to 80% of detrital grains, and 20% to 30% of cement. The minimum grain sizes are ranging from (0.08 mm to 0.12mm) and the maximum grain sizes are (0.16mm to 0.38mm) in diameter. Therefore the general grain sizes of the Okhmintaung sandstones are very fine- to medium-grained. Figure (5).

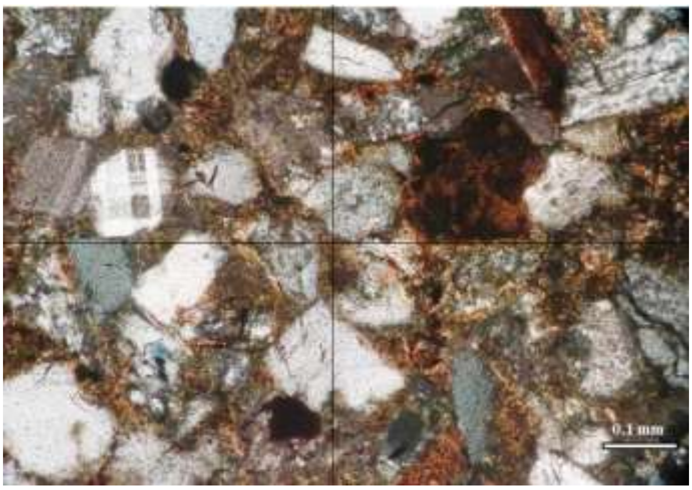


Figure 4 Photomicrograph showing sub-angular to sub-rounded with high sphericity of Padaung sandstone (Between X.N)

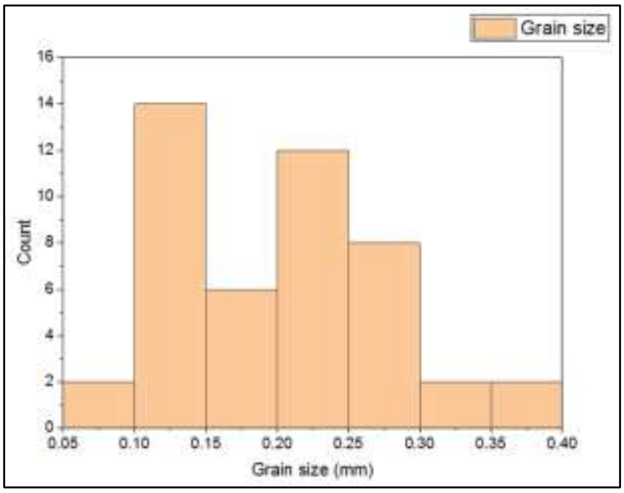


Figure 5 Average grain size of Okhminatung sandstones

Relationship between porosity, permeability, and grain sorting

According to the result of the petrograpic study, the grains of the Okhmintaung sandstones are moderate to well sorted by comparing with the effects of sorting and grain size on porosity and permeability (After Beard and Wely, 1973, Nagtegaal, 1978, and Simpson, 1995). Therefore, the porosity of the Okhmintaung sandstones may be fair to good. Figure (6). The average porosity and permeability of Okhmintaung sandstones are shown in figure (7).

Relationship between porosity, permeability, and grain packing

According to the result of the petrographic study, the grain packing of Okhmintaung sandstones is loose packing (cubic packing). It means that the porosity of the sandstone may be good. Figure (8).

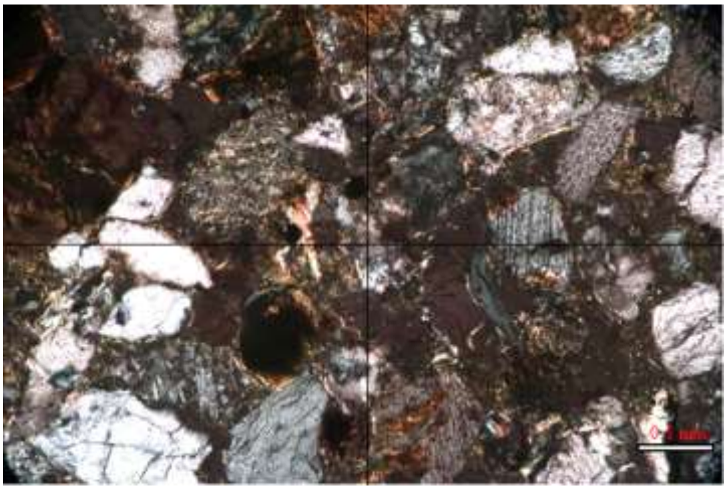


Figure 6 Photomicrograph showing moderate to well sorted sandstone of Okhminatung Formation

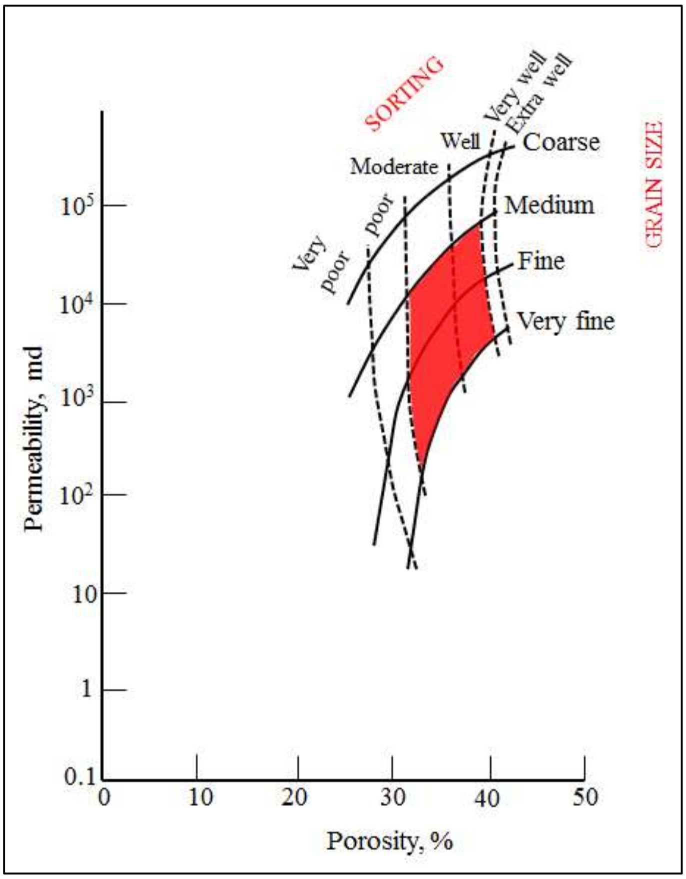


Figure 7 Graph of porosity against permeability of Okhmintaung Formation showing their relationship with grain size and sorting for uncemented sands. (After Beard and Weyl, 1973; Nagtegaal, 1978)

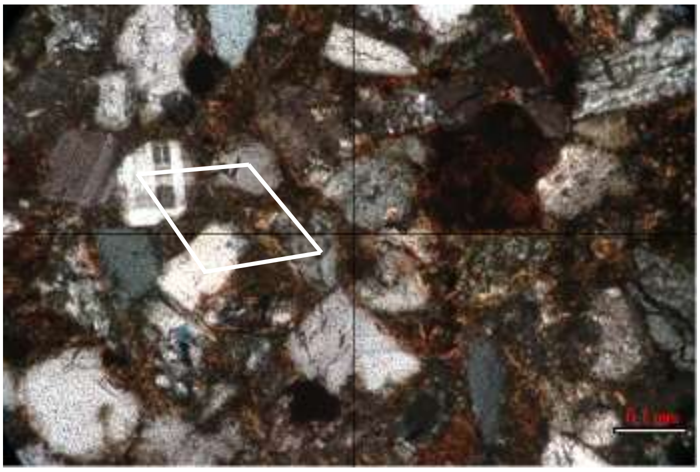


Figure 8 Photomicrograph showing the tight packing (rhombohedral packing) of Padaung sandstone

Effects of diagenesis on sandstone reservoirs of Okhmintaung Formation

The effects of diagenesis on sandstone reservoirs include the destruction of porosity by compaction and cementation, and the enhancement of porosity by solution.

Porosity loss by cementation of Okhmintaung Formation

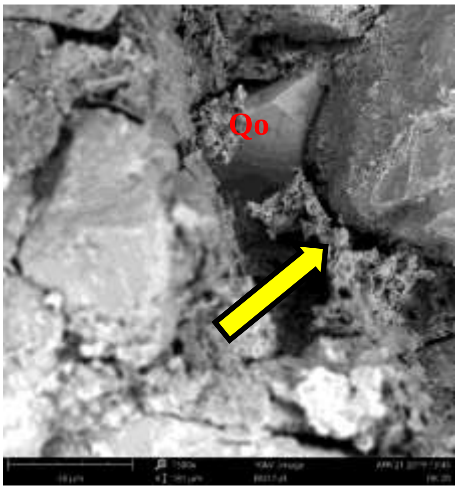
Calcite is one of the most common cement in the sandstones of Okhmintaung Formation. It generally occurs as calcite crystals, which, as they grow from pore to pore, may form a poikilitic fabric of crystals enclosing many sand grains. Grain boundaris are corroded, suggesting that some replacement has occurred. Calcite also occur infilling pores and microfractures.

Pore linings are occurred by clay coating deposited on the surface of detrital grains and the absence at points of grain to grain contact. The individual clay particle or aggregates commonly exhibit a preferred orientation normal to or parallel to the detrital grain surface (Wilson and Pittman, 1977).

According to the study of cementation in the Okhmintaung sandstone, minor pore-filling cements include chlorite and pyrite. Some feldspar grains are partially replaced by illite. Therefore, the Okhmintaung sandstones may have fair porosity but with anomalously may low permeability. Because of clay floccules have migrated to pore throats and then been cemented by pore-lining diagenetic chlorite and illite.

Figure 9 SEM image showing the kaolinite clay mineral fill the pore spaces (K)

Figure 10 SEM image showing the grains are coated by early clay mineral (arrow)



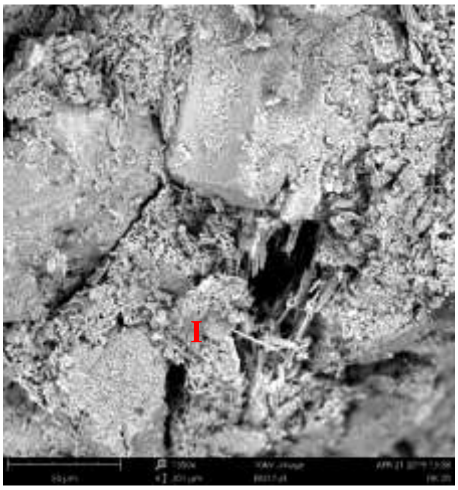


Figure 11 SEM image showing clay mineral occurs as a selective grain-replactive mineral and is also attached to grain surfaces and fill the pore, and quartz grain has the secondary overgrowth (Qo).

Figure 12 SEM image showing the clay mineral illite (I) fill the pore space

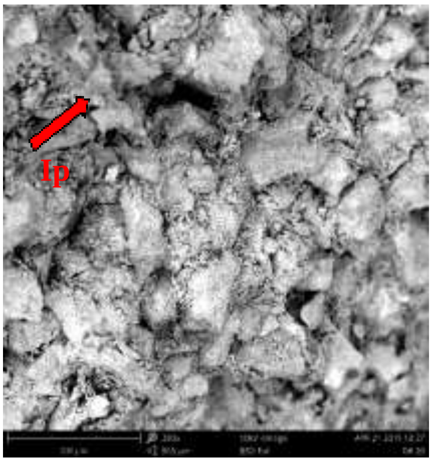
Porosity and Permeability Analysis by Digital Image Analysis (DIA) of Okhmintaung Formation

Massive sandstone body (total 15 m thick)

The pore spaces of massive sandstone body are represented mainly by intergranular porosity, intragranular porosity, and connected porosity. The pore quality is controlled by the effects of compaction, and relative amounts or cements and matrix. Figure (13), and (14). The values of porosity and permeability by DIA method is shown in table (1).

Table 1 Porosity and permeability value of massive sandstone, OK20 by the DIA method

No	Pore Diametre (µm)	Interconnected Porosity (%)	Total Porosity (%)	Permeability (μm^2)	Permeability (md)
OK20	40.90822387	3.217	19.001	1.68237316	1.70E+02



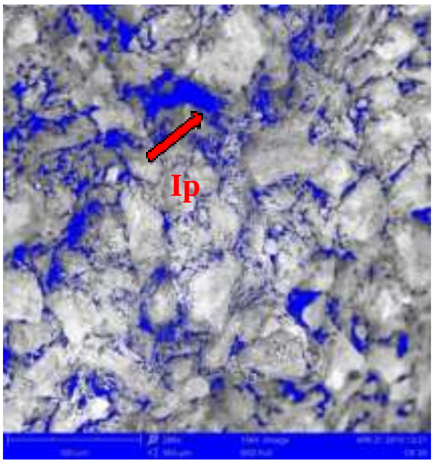


Figure 13 SEM image showing intergranular pore space (Ip) before image analysis

Figure 14 SEM image showing intergranular pore space (Ip) after image analysis

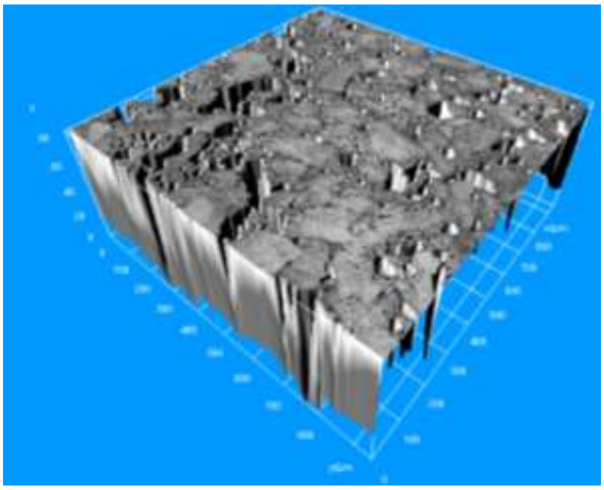


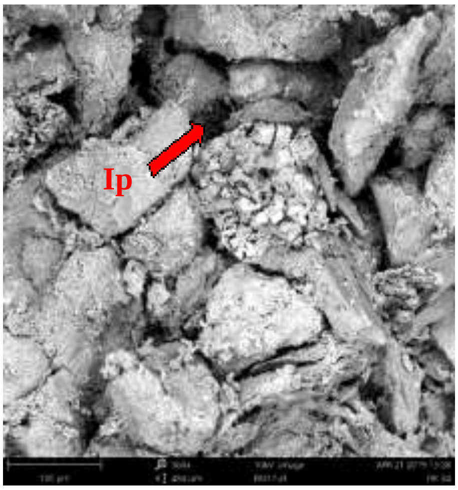
Figure 15 3D image showing the pore network structure of massive sandstone, OK20 to calculate the permeability

Thick-bedded to massive sandstone body (about 20 m thick)

The pore spaces of thick-bedded to massive sandstone body are represented mainly by intergranular porosity, intragranular porosity, and connected porosity. In the case of this study, the former unstable grains have dissolved at a late diagenetic stage creating secondary pores. The pore quality is controlled by the effects of compaction, and relative amounts or cements and matrix. Figure (16), and figure (17). The values of porosity and permeability by DIA method is shown in table (2).

Table 2 Porosity and permeability value of thick-bedded to massive sandstone, OK21 by the DIA method

No	Pore Diametre (µm)	Interconnected Porosity (%)	Total Porosity (%)	Permeability (μm^2)	Permeability (md)
OK21	35.601877	8.34	21.824	3.30340532	3.35E+03



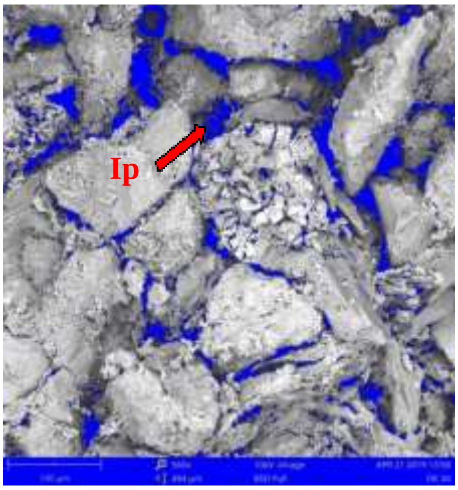


Figure 16 SEM image showing intergranular pore space (Ip) before image analysis

Figure 17 SEM image showing intergranular pore space (Ip) after image analysis

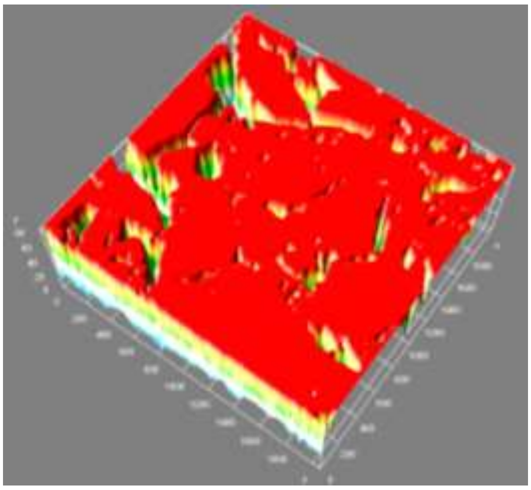


Figure 18 3D image showing the pore network structure of thick-bedded to massive sandstone, OK21 to calculate the permeability

Porosity and permeability of Okhmintaung Formation

Table 3 Summery of porosity and permeability of Oligocene strata

No	Pore Diametre (µm)	Interconnected Porosity (%)	Total Porosity (%)	Permeability (µm^2)	Permeability (md)
OK21	35.601877	8.34	21.824	3.303405315	3.35E+03
OK20	40.90822387	3.217	19.001	1.682373158	1.70E+02
PD19A	48.3184411	3.252	13.371	2.372610166	2.40E+03
PD19	18.93317673	3.45	17.791	0.386470273	3.92E+02
PD18	51.77055799	3.953	15.517	3.310873043	3.35E+03
SZT16	11.19279206	6.79	13.212	0.265825517	2.69E+02
SZT15	134.9259999	9.565	26.307	54.41595887	5.51E+04
SZT12	55.21516738	10.953	30.571	10.43517882	1.06E+04
SZT6	92.34526735	13.747	33.849	36.63424456	3.71E+04

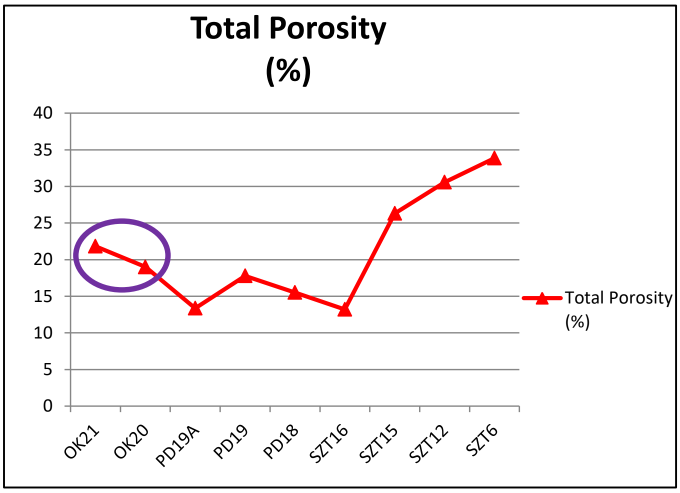


Figure 19 Showing the total porosity of sandstone from the Oligocene strata

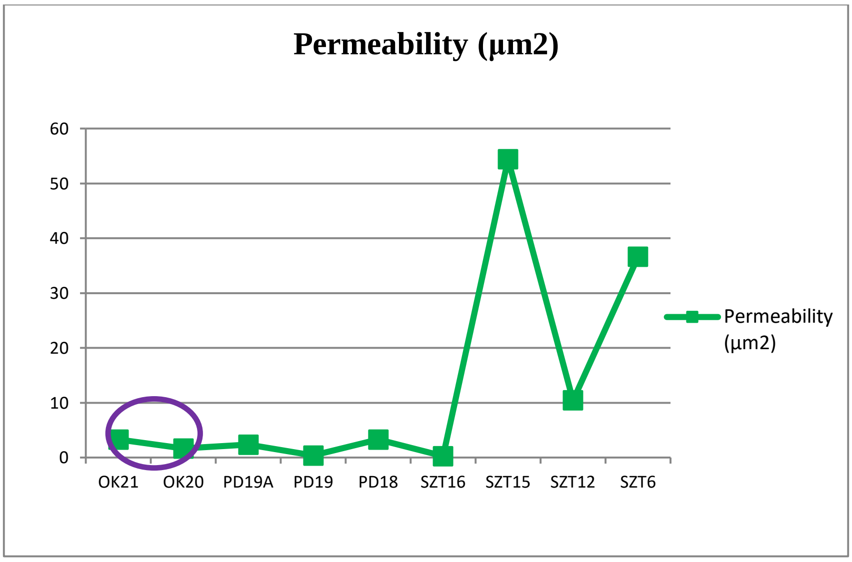


Figure 20 Showing the permeability of sandstone from the Oligocene strata

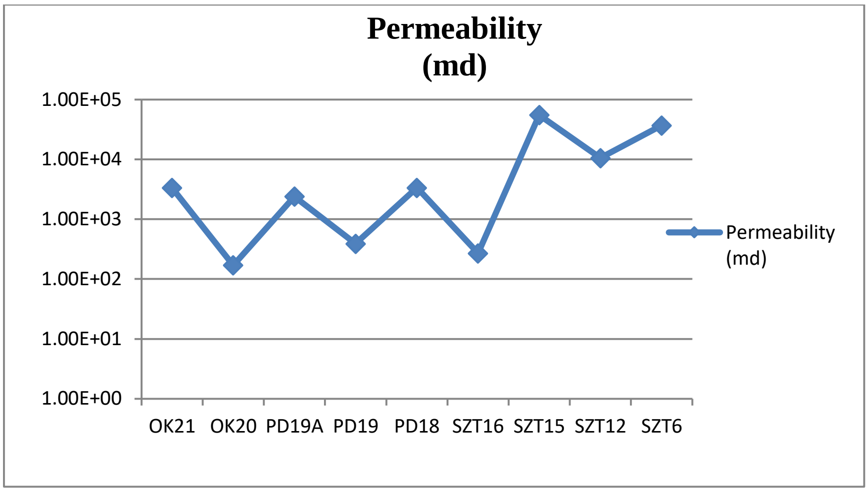


Figure 21 Showing the permeability of sandstone from the Oligocene strata

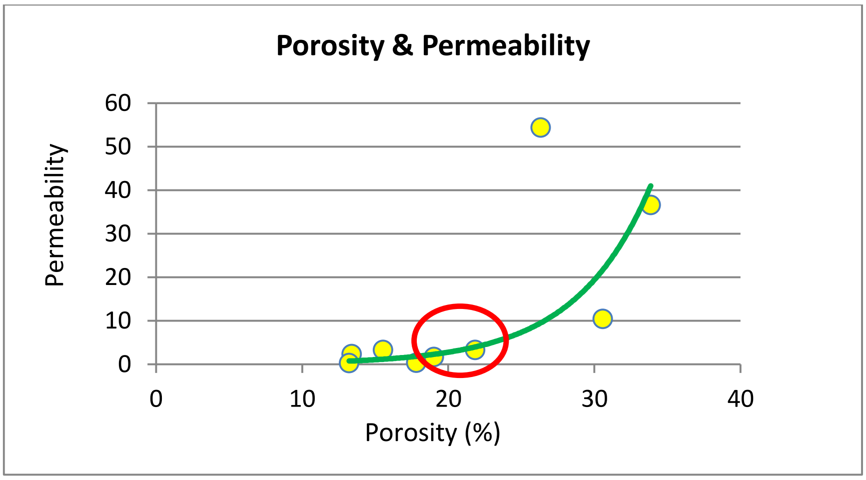


Figure 22 Relationship between porosity and permeability of sandstone from the Oligocene strata

Summary and Conclusions

By the petrographic texture, porosity, and diagenetic features enhancing or destroying the potential porosity of the sand body are also started. Some of the sand bodies do not favor the potential of good reservoir because of the size, textural features and diagenetic imprints. Some of the reservoir cannot regarded as medium potential due to the petrographic fabric forming lesser potential.

By studying the diagenetic features, some of the Okhmintaung sandstone possesses pore-filling clays and very thin grain coating. These authigenesis can destroy reservoir potential and cannot regarded as medium potential due to the petrographic fabric forming lesser potential. The textural features suggest that Okhmintaung sandstones are fair reservoir.

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