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Research Article

CHEMOSTRATIGRAPHY OF FIELDS X AND Y, AGBADA FORMATION, ONSHORE NIGER DELTA BASIN

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ABSTRACT

The chemical stratigraphy of some reservoirs in fields X and Y, Agbada Formation, Niger Delta was carried out using results from Xray Fluorescence (XRF), Atomic Absorption Spectrometry (AAS), Scanning Electron Microscopy (SEM) and Petrography. The results showed that deep subsurface Agbada Formation reservoirs were more mature and have better reservoir characteristics than shallow subsurface Agbada Formation and four chemostratigraphic zones were identified in the chronologically stacked reservoirs. These chemostratigraphic zones have unique elemental composition that may affect the reservoirs flow ability.

Keywords: Chemostratigraphy, Chemostrat Zones, Chemical Stratigraphy, Agbada Formation, Niger Delta, reservoirs, reservoir quality.

INTRODUCTION

Geochemistry and chemostratigraphy have proven to be useful tools among others for understanding geological history of parasequences around the world. Although geochemistry has been used to understand basic geological history of sediments, the characterization of depositional parasequences based on chemical stratigraphic traits and variations have been a bit more recent from the 1980s (Ramkumar, 2015). Chemostratigraphy uses sedimentary rocks' chemical fingerprints and stable isotope signatures such as those of oxygen and carbon used for paleoclimate; and the isotope of carbon for global carbon cycle inferences (Weissert et al, 2008). This tool has been used by many researchers to unravel the development of parasequences by correlating well constrained marine strata with poorly understood vertically stacked parasols for understanding the eustatic sea level variations (Morath et al, 2015; Ramkumar et al, 2015).

The study area:

The wells used for the study are; Y and X representing fields X and Y respectively and they geographically lie within the South-South and South-East Geopolitical zones respectively (Figure 1. The samples were retrieved from core shed of the National Geosciences Research Laboratories (NGRL), a centre of Nigerian Geological Survey Agency (NGSA) in Kaduna.

The rifting of South America from Africa started in Early Cretaceous and continued till Late Cretaceous this created the tectonic accommodation space for Niger Delta Basin (Genik, 1993; Brownfield, 2016). After this period, gravity became the primary deformational process which ended before the deposition of Benin Formation. Core description and analysis of the basins subsurface formation have shown three dominant formations: Akata, Agbada and Benin Formations. Akata Formation the oldest of the tripartite group is composed mainly of shale with some pockets of sand and is known to be the main hydrocarbon source rock in the basin. Agbada Formation is composed of almost the same amount of sand and shale and it is regarded as the main hydrocarbon reservoir. Benin Formation has more than 70% sand is forms most the overburden needed for the generation of hydrocarbon in the basin.

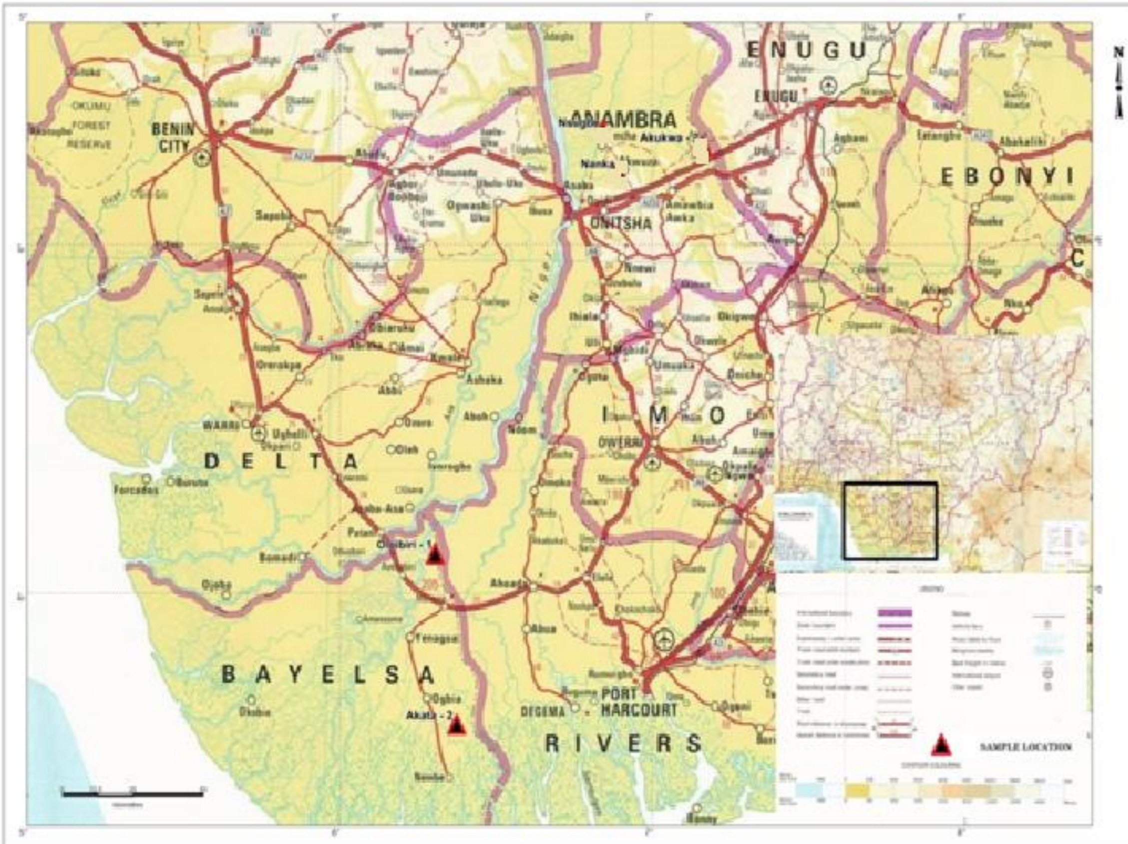


Figure 1: Location of the study area

The geology of Niger Delta has been well studied due to its vast petroleum resources by previous workers such Tuttle, 1999; Nwajide, 1977, 1985 and 2013; Brownfield, 2016; using both cores description and analysis of the subsurface Niger Delta (Akata, Agbada and Benin Formations); and outcrop studies of surface formations (the Ameki Group comprising of the Ameki Formation, Nanka Formation and Nsugbe Formation; Ogwashi-Asaba and Imo Formation) in the basin for its sedimentological features. The structural features as well as the tectonic history have been studied using more of geophysical and remote sensing data, gravity tectonics is displayed in different complex structures that act as traps for hydrocarbon such as shale diapirs, rollover anticlines, collapsed growth faults and back-to-back features (Doust and Omatsola, 1990; Stacher, 1995; Brownfield, 2016).

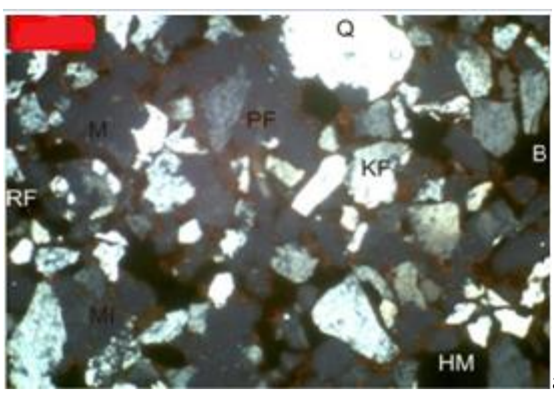
MATERIALS AND METHODS

Core samples and drill cuttings from subsurface Agbada Formation; and rock samples from outcrop The shallowest reservoirs of Ameki Group representing surface Agbada Formation were analysed. Analysis equipments such as X-Ray Diffractometer, X-Ray Florescence Spectrometer, Atomic Absorption Spectrometer, Scanning Electron Microscope, and Petrographic microscope were used to determine the elemental and mineralogical composition of the samples.

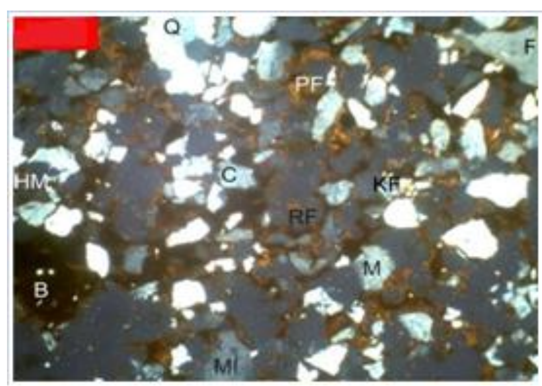
RESULTS AND DISCUSSION

Results of the Photomicrographs (Figures 2a-h) showed that shallow reservoirs of Y subsurface well analysed displayed a lot more variability in sizes than those of well X indicating poorer sorting. At a shallow depth of 6611feet, Y well which is Agbada Formation reservoir displayed many of fractured minerals, this may be pointers to the occurrence high pressure effects. This reservoir also showed roundness ranging from angular to subrounded grains. The discrepancies in particle sizes as observed in the Photomicrographs are indicative of very poor sorting. Y deep reservoir sample also showed various size ranges which could be inferred as ranging from poorly to moderately sorted and the particles shape ranged almost uniformly from subangular to subrounded. Approximately the same minerals were present at both reservoirs depths, they were Quartz, Biotite, Muscovite, Orthoclase Feldspar, Haematite and rock fragments; and seen in them were cement and mineral inclusions. However, Plagioclase Feldspar existed more in the shallow Y reservoir than in deeper ones which is indicative of more maturity for the deep reservoirs. As it was in X well, the Agbada Formation encountered by Y well showed better reservoir qualities in greater depths than the shallow ones, this may correspond to greater hydrocarbon in place.

Scanning Electron Microscopy was carried out in three samples (Figures 3a-f) of Agbada Formation reservoirs encountered by Y well and X well. Moving from the up dip to down dip, the shallowest as observed showed weblike structures which are mostly Smectite, filamentous Illite and Kaolinite lining the particles walls and the inter-particle pores. The rock particles of the shallowest reservoir show roundness of Subangular to Subrounded. Smectite which is swelling clay can greatly reduce reservoir qualities and build uneven pressure while chlorite lining reduces mostly permeability. Chlorite coating can cover dentrital grains from dissolution caused by fluid injection. Generally, clays reduce permeability and porosity and could raise completions problems. Most particle lining, mineral bridging and pore filling minerals were observed in the shallow reservoirs as compared to deep reservoirs.



a



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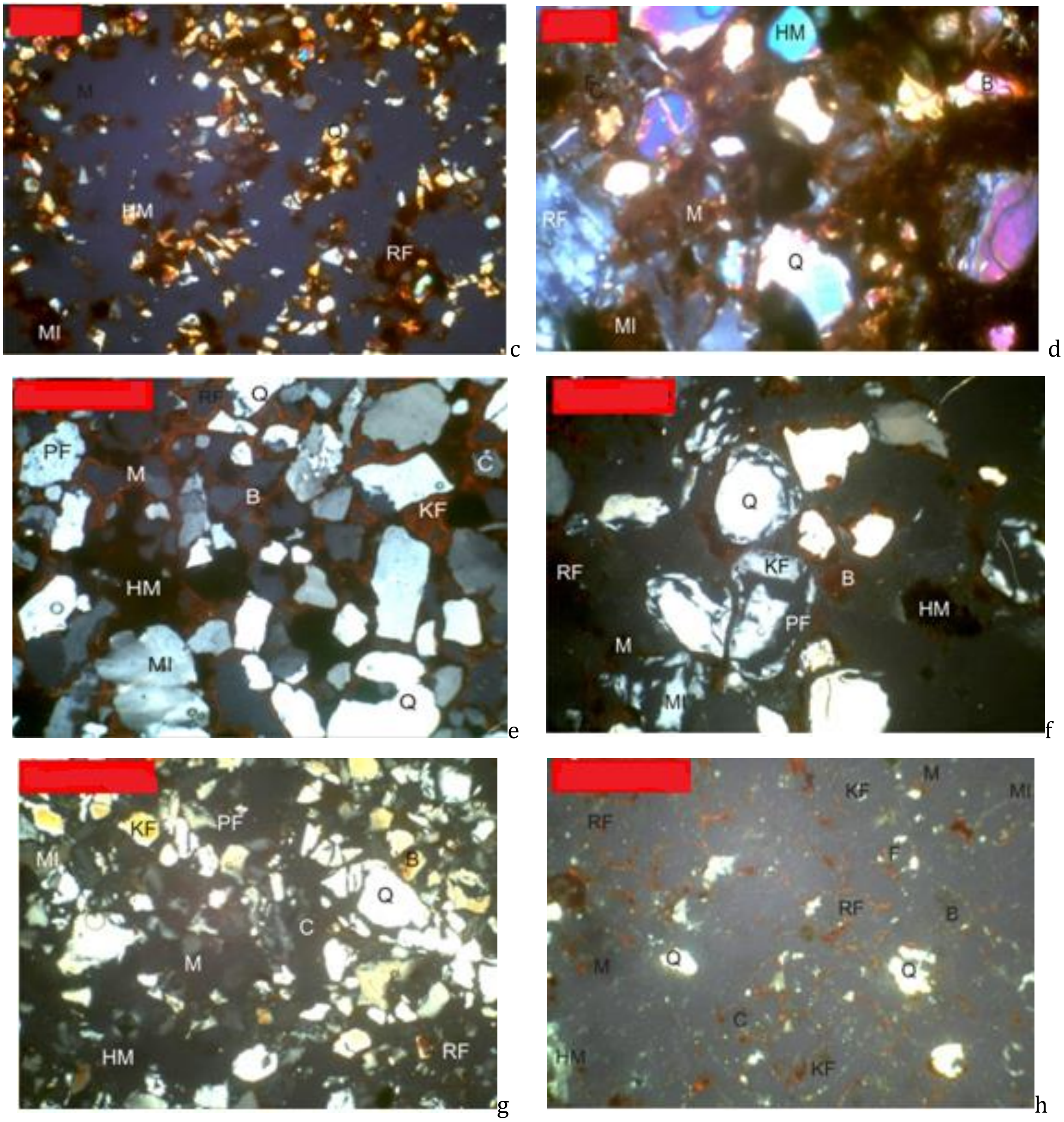
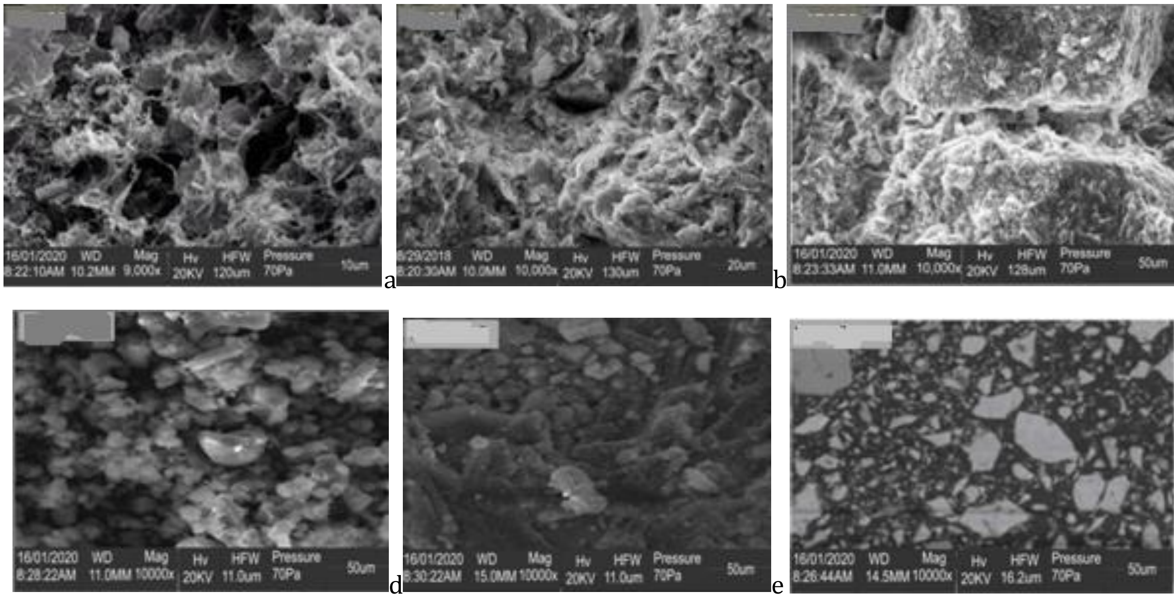


Figures 2a-h: Photomicrographs of the studied reservoirs

WELLS (Depth in Feet)	SiO2	Al2O3	TiO2	Fe2O3	CaO	Na2O	K2O	MnO	P2O5	MgO	LOI	CIA	PIA	CIW	ICV	Qm	Qt	F	L	RF
Y(6611)	46.90	37.6	0.09	0.88	0.03	0.21	1.6	N/A	0	0.05	9.75	95.33	91.28	99.4	N/A	20	57	15	3	10
Y (6661)	96.36	3.04	0.06	0.48	0.19	0.11	0.66	0.01	0.57	0.28	-	75.82	59.19	90.9	0.595	22	64	15	2	8
Y (7368)	94.00	1.04	0.23	1.24	0.77	0.53	0.68	0.04	0.64	1.36	-	34.44	11.92	44.4	4.663	-	-	-	-	-
X (7300)	54.97	25.11	0.01	2.52	0.1	1.88	0.13	0.04	0.22	0.51	9.75	92.25	91.77	92.7	0.207	14	60	14	2	10
X (7478)	87.77	2.74	0.06	0.38	4.07	0.6	1.02	0.05	0.63	3.9	-	32.5	20.4	37	3.679	12	57	21	2	10
X (7926)	93.55	4.71	0.17	1.12	0.13	0.43	0.88	0.02	0.8	0.53	-	76.7	62.46	89.4	0.692	-	-	-	-	-

Table 1: A summary of the elemental and mineralogy composition and concentrations of the samples



Figures 3a-f: SEM results of the studied reservoirs

Chemostratigraphic packages:

From the elemental composition of the studied reservoirs, the geochemical signatures were used to identify four chemozones (Figure 57 below), namely; Chemozone-1, Chemozone-2, Chemozone-3 and Chemozone-4. Below are the characteristics of these zones.

Chemozone 1: This chemostratigraphic zone represents the oldest reservoirs (Mamu Formation and the base of Agbada Formation) analysed. It is signified by the lowest aluminium oxide, titanium oxide and iron oxide. There were moderate concentrations of sodium oxide, potassium oxide, manganese oxide and magnesium oxide. This zone is also unique for its highest concentration of silicon oxide, phosphorus oxide and calcium oxide.

Chemozone 2: It is close to the middle section of Agbada Formation analysed, and it was noted to be bearing the highest concentration of silicon oxide. This is typical of mature sediments. There were moderate concentrations of oxides of aluminium, sodium, potassium, manganese and phosphorus. Oxides of titanium, iron, calcium and magnesium had their lowest concentrations in this zone.

Chemozone 3: This represents the top of Agbada Formation analysed. Its chemostratigraphic signatures show highest concentrations of aluminium oxide and potassium oxide. Silicon oxide had a moderate concentration in this zone while oxides of titanium, iron, calcium, sodium, phosphorus and magnesium showed their lowest values.

Chemozone 4: This is composed of the shallowest reservoirs of Agbada Formation. The zone has the lowest concentration of silicon oxide whereas it had the highest values of oxides of calcium, magnesium, iron and titanium. There were also some moderate concentrations of aluminium oxide, sodium oxide, potassium oxide and manganese oxide.

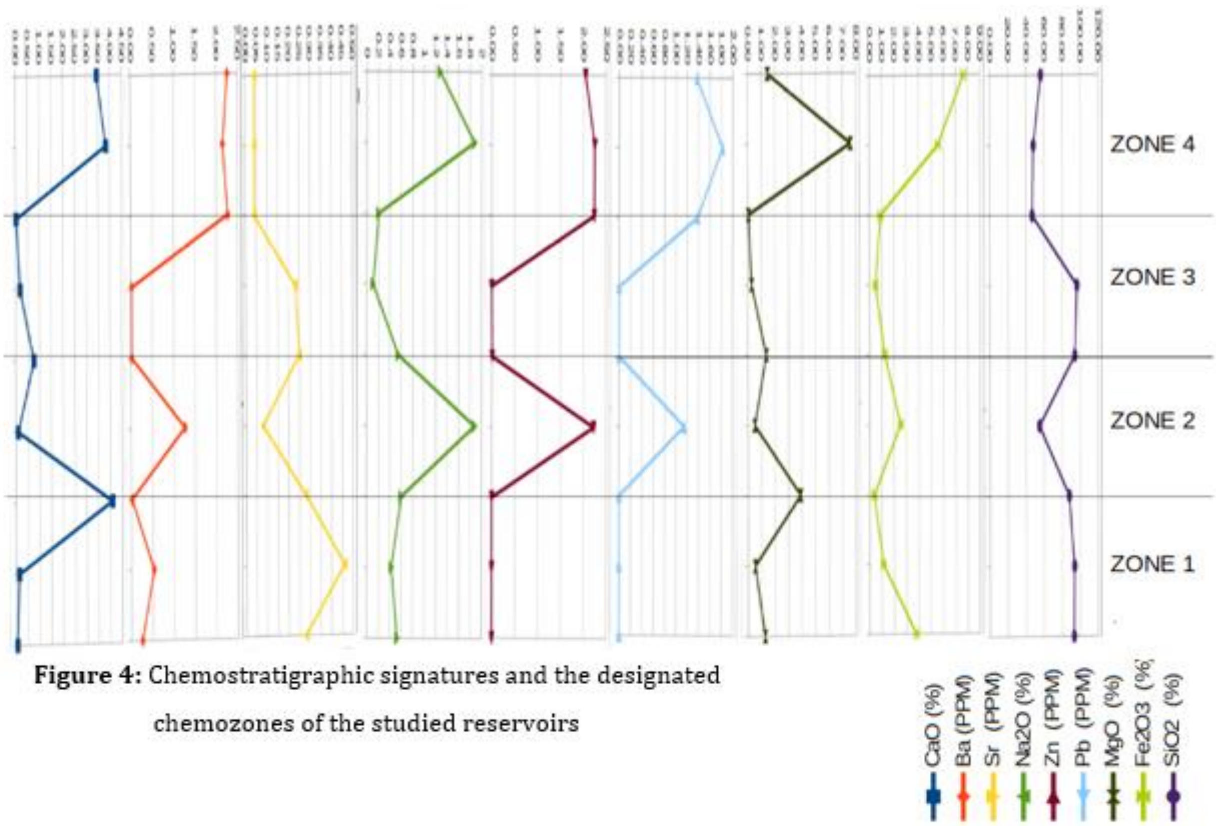


Figure 4: Chemostratigraphic signatures and the designated chemozones of the studied reservoirs

CONCLUSION

Clay minerals were seen to line particles wall and fill pore spaces mostly in the shallow reservoir samples than in the deep reservoirs thereby reducing the reservoir quality. The chronologically stacked sequence of the studied Agbada Formation reservoirs showed four distinct signature packages, it was therefore divided into four chemostratigraphic packages based on their elemental signatures; Chemostrat package 1, Chemostrat package 2, Chemostrat package 3 and Chemostrat package 4 using elemental concentrations of oxides of silicon, aluminium, titanium, iron, calcium, sodium, potassium, manganese, phosphorus and magnesium. The first is unique for its highest Strontium value and lowest Lead and Zinc values. The second has signatures of almost constant Calcium and Magnesium oxides. The third package showed a fluctuating signature for almost all the elements and elemental oxides; Barium, Strontium; and the oxides of Calcium, Magnesium, Sodium, Lead, Iron and Silicon. Lastly, the fourth Chemostrat package which is the shallowest of the analysed reservoirs showed the highest Barium, Calcium Oxide and Magnesium Oxide concentrations.

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