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Depositional Environment And Geochemistry Of The Yolde Formation Of Gabukka Village, Gongola Sub-Basin, Northern Benue Trough, Northeastern Nigeria

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Abstract:
Ten representative samples of Yolde formation exposed at Gabukka village were analyzed for major oxides (Al_2O_3, SiO_2, K_2O, CaO, Fe_2O, Na_2 O, MgO, MnO, P_2O_5, $TiO_2$and Cl) using X-ray fluorescence (XRF). The major oxide concentration indicate dominance of Cl ranges from 177 to 367 with (avg. 257.2 wt. %), SiO_2 ranges from 62.5 to 70.3 with (avg. 66.46 wt. %), Al_2O_3 content ranges from 18.5 to 21 with (avg. 20.17 wt. %).Fe_2O_3 ranges from 2.29 to 5.78 with (avg. 4.515 wt. %).K_2O, Cao, and TiO_2 have an average concentration of 3.805, 1.5708 and 1.361 wt. % respectively, whereas MgO, Na_2O, P_2O_5 and MnO are present with average values of less than 1. The low values might perhaps be the result of post depositional processes or from sediment source. Geochemical results show that the average value of chlorine and silica is far higher than the average values of the rest oxides. Silica enrichment is a measure of sandstone maturity, and is a reflection of the duration and intensity of weathering and destruction of other minerals during transportation. Major oxide ratios reveals passive Continental margin, quartz arenite, sublith-arenite, lith-arenite and Fe-rich sandstones derive from pre-existing igneous rock and sediments had mixed marine and terrigenous source input deposited mainly in humid climatic condition.

Keyword:*Yolde formation, Gabukka, Geochemistry, Gombe*

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I. INTRODUCTION

The depositional environment is a geomorphic unit in which deposition takes place. The layers of sediment that accumulate in each type of depositional environmental have distinctive characteristic, which provide important information regarding the geologic history of an area. These sediments, form at the surface and provide information about the past environment (Balasubramanian and Mahesha, 2013). Geochemistry is concerned with physic-chemical principles that influence and/or control the origin, migration, deposition and distribution of chemical elements (and their isotopes) in the various spheres of the earth (Michael and Russell, 2020). The study area lies within the Gongola arm of the Upper Benue Trough which is separated from Chad Basin by the Zambuk ridge where the strata are reduced in thickness and in some places the ridges are represented by discontinuous line of genetic basement inliers. The sediments are Cretaceous to tertiary in age ranging from Albian to Paleocene and are said to have been deposited on the Pre-Cambrian basement complex (Zaborski, 1998).

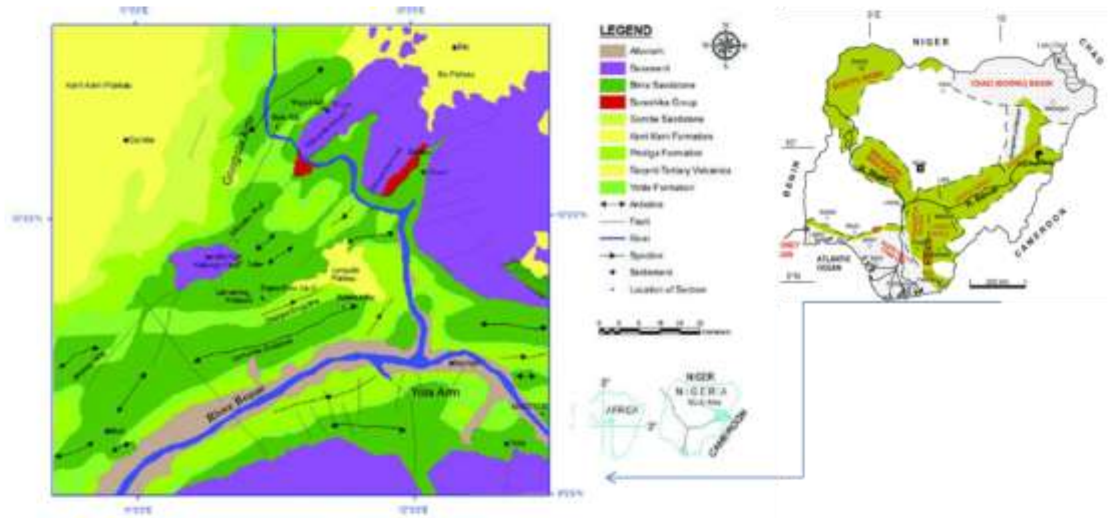
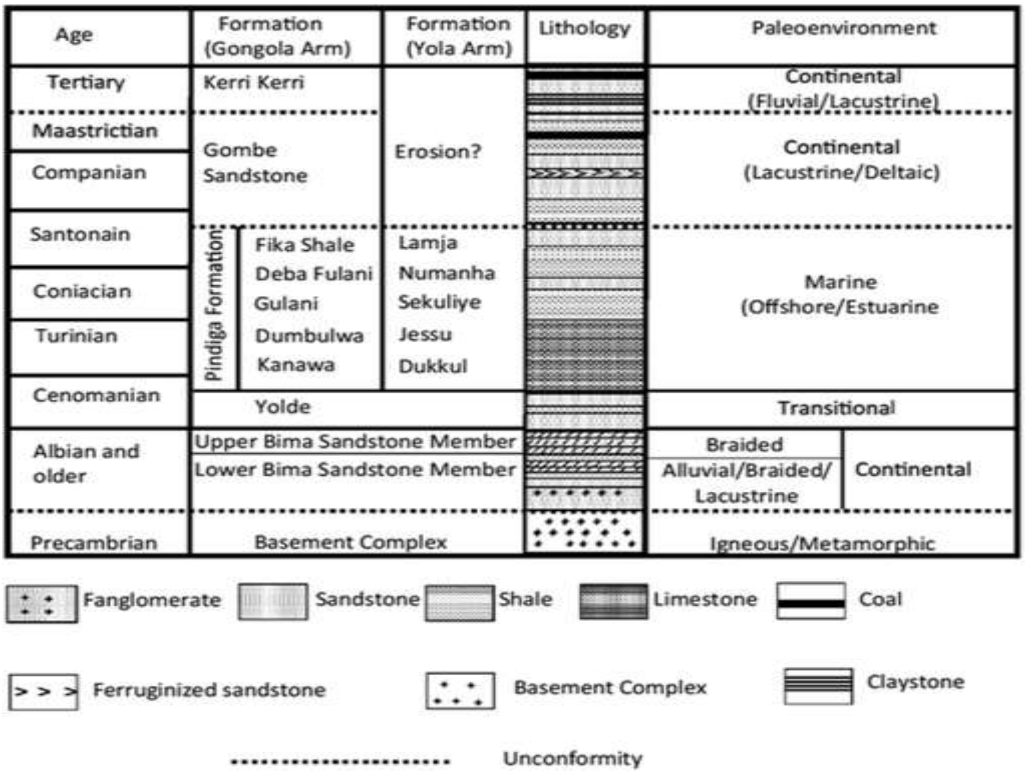


Figure 1: GeologicMap of the Upper Benue Trough(Tukur, *et. al.* 2015) Insert: Geologic Map of Nigeria (Obaje, 2009)

II. REGIONAL GEOLOGY AND STRATIGRAPHY

The Benue Trough is a major NE-SW trending sedimentary basin 50 – 150km wide. It extends for over 1000km from the Niger-Delta to Lake Chad (Guiraud, 1990). At the northern end of the trough which constitutes the Upper Benue Trough, the basin bifurcates into a Gongola branch striking N-S into Lake Chad and E-W Yola branch, trending towards Yola and into Cameroon along River Benue (Figure 1). The geology of the Upper Benue Trough as it relates to its origin and tectonic invention have been discussed in detail by (Guiraud, 1990). The Gongola arm which is separated from the Chad basin to the North by the Zambuk ridge is linked to the West African Rift system through Niger and Chad Republic (Zaborski et al., 1997). The regional stratigraphy of the area was summarizedby Guiraud (1990); the Bima sandstone lies unconformably on the Precambrian basement complex and consist of three siliclastic members; the lower (B1) the middle Bima (B2) and the upper Bima (B3). Overlyingthe Bima sandstone is the Yolde Formation which is Cenomanian in age; andit marks the transition between the continental environment and the major Turonian transgression. It consists of a variable sequence of thinly bedded sandstone, sandy mudstone and shally limestone. The formation overlies the Bima sandstone in both Gombe and Numan areas, but absent around Fika. At its type locality, it is exposed in a stream at Yolde where thick sedimentation is present. It has an average thickness of about 213m (Shettima *et al*., 2007). Its major mineral composition is quartz, feldspar and Clay mineral. The Pindiga Formation overlies the Yolde Formation in the Gombe areas. According to (Carter *et al*., 1963; and Obaje *et al.*, 2000), the Pindinga Formation is the lateral equivalent of the Gongila and the Fika formation in the Fika areas, Chad Basin and marine sequences (Dukkul,Jessu, Sekuliye, Numan and Lamja formations) in the Yola Arm.Overlying the Pindiga Formation is the Gombe sandstone and it is overlain by the Kerri-Kerri Formation (Table 1).

Table 1: Lithostratigraphic succession of the Upper Benue Trough, with a new stratigraphic subdivision of the Bima Sandstone (Samaila *et al.* 2007)



III. MATERIALS AND METHODS

Detail geological mapping was carried out in the field. During the field work, traverses were taken with the aid of a compass along footpaths, road cuts, rail cuts and river channels to locate sections of Yolde Formation at Gabukka Stream. Observation and logging of different sections was done, measuring the thicknesses of individual beds, describing the lithology and measuring the paleocurrent direction. Samples were taken at points of interest, labeled properly, bagged and brought back. Ten (10) samples from the Yolde Formation field consisting of mudstones and sandstones were selected and taken to the laboratory and analyzed using X-ray Fluorescence (XRF) for major oxides and chlorine.

IV. RESULTS AND DISCUSSION

Ten (10) representative samples of the Yolde Formation exposed at Gabukka village was analyzed for major oxides (Table 2). The major oxide concentration indicates dominance of Cl and ranges from 177 to 367 with (avg. 257.2 wt. %), SiO_2 ranges from 62.5 to 70.3 with (avg. 66.46 wt.%). According to Lindsy, (1999), silica enhancement shows the degree of sandstone maturity, and the reflection of the extent and strength of weathering and damages of other minerals in the course of transportation. Al_2O_3 content ranges from 18.5 to 21 with (avg. 20.17 wt.%). Cingolani *et al*., (2003), opined that the compositional variations of rocks arising from weathering result in the reduction of alkalis and alkaline earth elements and special enhancement of $Al_2O_3$and Fe_2O_3 ranges from 2.29 to 5.78 with (avg. 4.515 wt.%). K_2O, CaO, and TiO_2 have an average concentration of 3.805, 1.5708, and 1.361 wt. %, respectively. The low content may be due to weathering whereas MgO, Na_2O, P_2O_5 and MnO are present with average values of less than 1. The low values might perhaps be the result of post depositional processes or from sediment source.From the preceding, the mean value of silica (66.46 wt. %) in the studied sediments is extremely higher than the mean values of the remaining oxides with the exception chlorine, probably due to weathering and post depositional processes, as sedimentary rocks are enriched in silica and reduction in iron, magnesium, calcium, sodium and potassium in association to the sediment source. The results obtained shows that the samples are highly rich in Cl, $SiO_2$and Al_2O_3. Likewise it has depleted MgO and MnO.

Table 2: The geochemical result of major elements and chlorine of the Yolde Formation

Sample ID	Na_2O	MgO	AL_2O_3	SiO_2	P_2O_5	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3

X37	0.671	0.827	18.5	69.8	0.0708	332	3.85	0.781	1.27	0.0746	3.76
X33A	0.518	0.639	21	65.4	0.0661	367	3.66	1.94	1.27	0.0796	5.03
X34	0.49	0.588	21	65.2	0.0647	353	3.59	2.34	1.23	0.0431	5.12
X36	0.683	1.17	19.8	66.6	0.101	177	3.43	1.05	1.66	0.0742	5.05
X38	0.841	0.646	20.2	66.9	0.164	236	3.14	1.2	1.51	0.0445	4.81
GB24	0.329	1.16	19.9	66	0.116	186	3.59	1.1	1.58	0.11	5.78
X33	0.474	0.561	20.9	65.4	0.0936	361	3.85	1.76	1.32	0.065	5.22
X35	0.422	1.14	19.8	66.5	0.104	199	3.37	1.16	1.56	0.208	5.21
GB23	1.23	0.426	21.4	62.5	2.28	181	4.8	3.67	1.01	0.0216	2.29
X40	0.196	0.327	19.2	70.3	0.0694	180	4.77	0.707	1.2	0.0316	2.88
Average	**0.585**	**0.748**	**20.17**	**66.46**	**0.31296**	**257.2**	**3.805**	**1.570**	**1.361**	**0.075**	**4.515**

The following plots show the concentration of the major oxides.

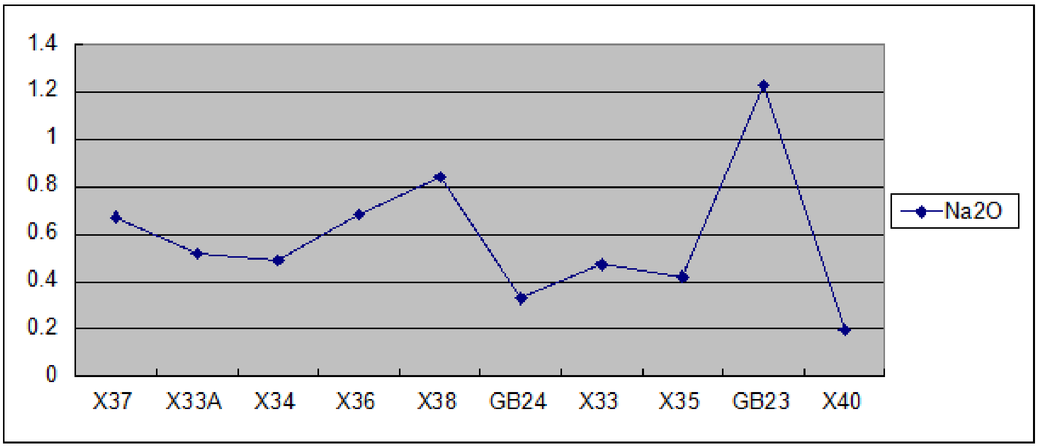


Fig. 3: Plot showing the concentration of Na_2O

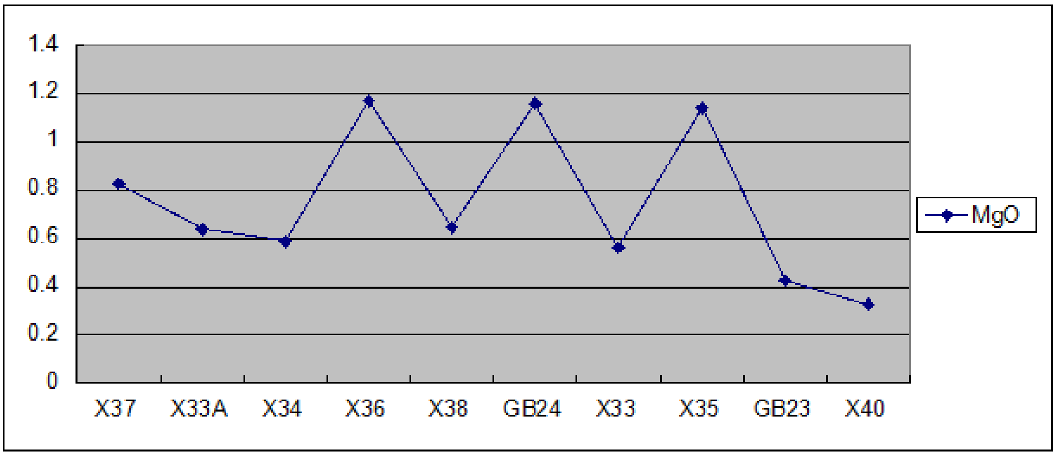


Fig 4: Plot showing the concentration of MgO

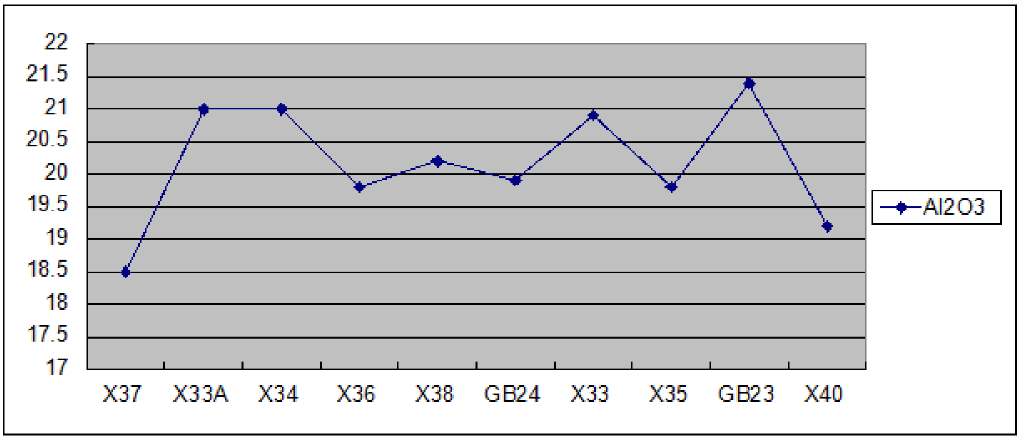


Fig 5: Plot showing the concentration of Al_2O_3

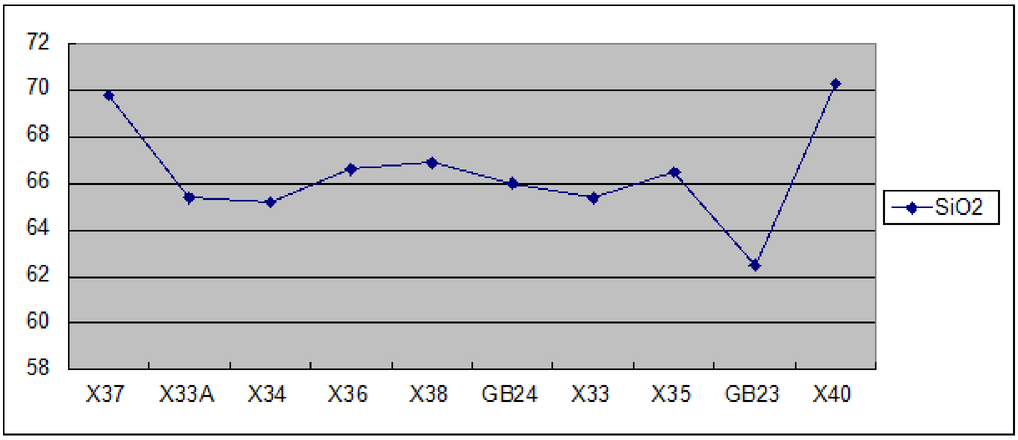


Fig 6: Plot showing the concentration of SiO_2

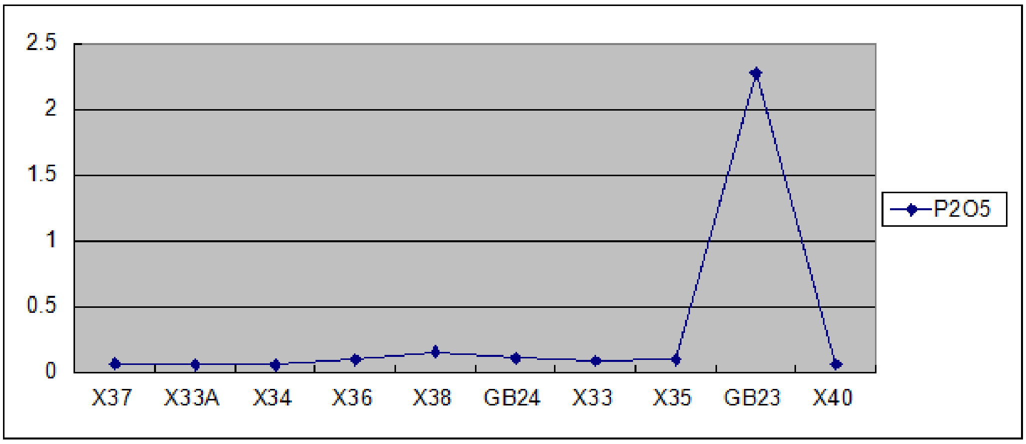


Fig 7: Plot sowing the concentration of P_2O_5

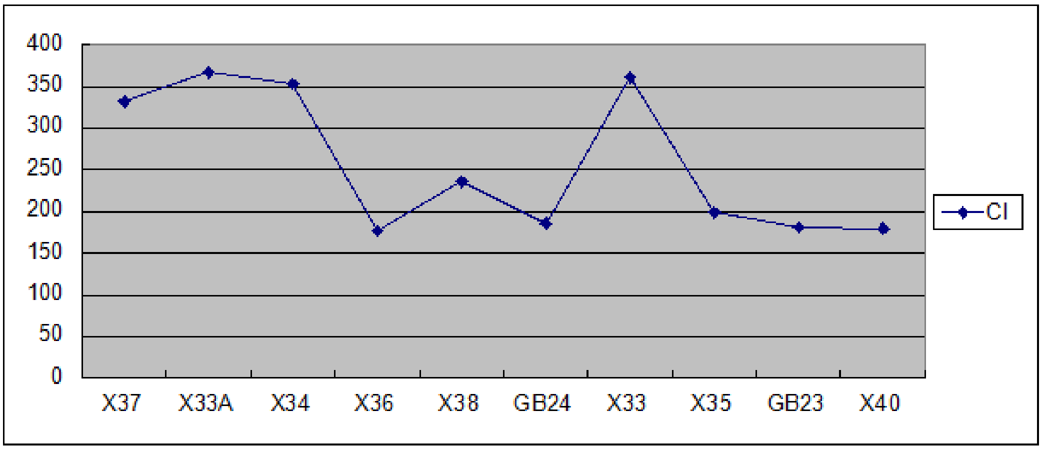


Fig 8: Plot showing the concentration of Cl

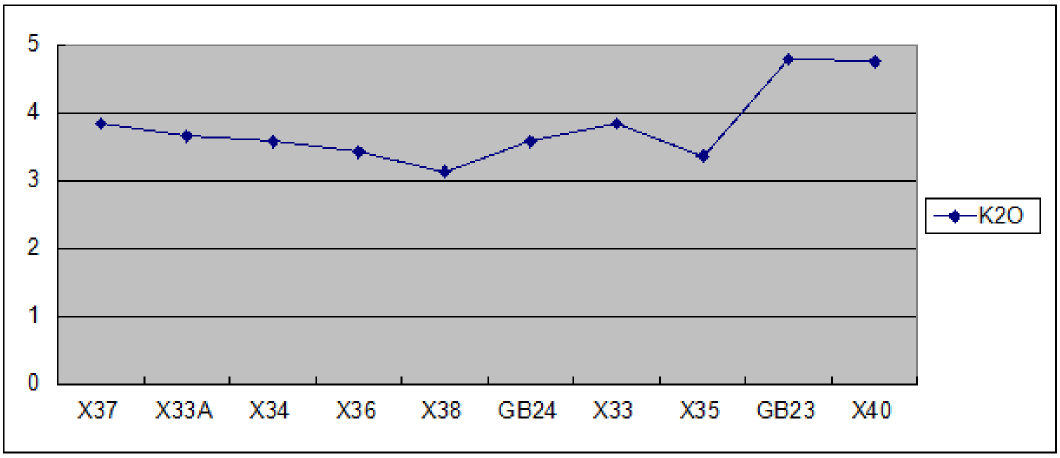


Fig 9: Plot showing the concentration of K_2O

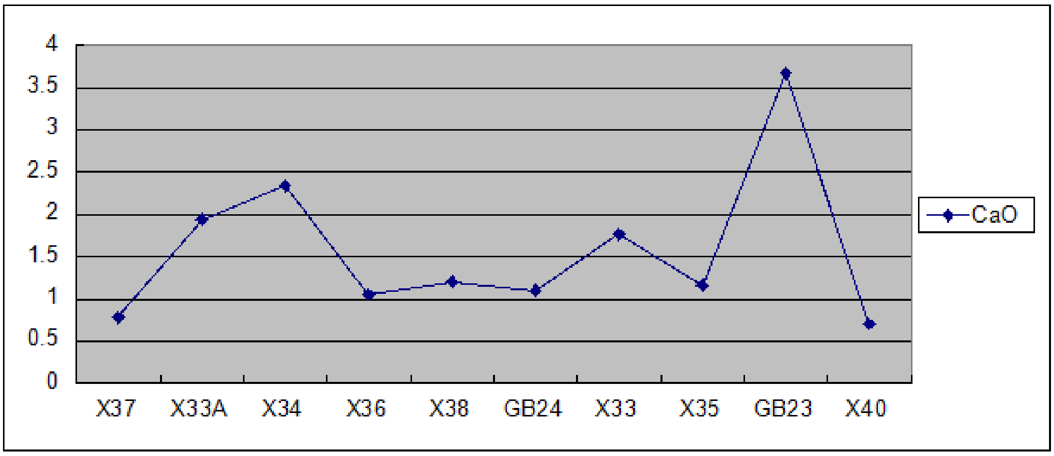


Fig 10: Plot showing the concentration of CaO

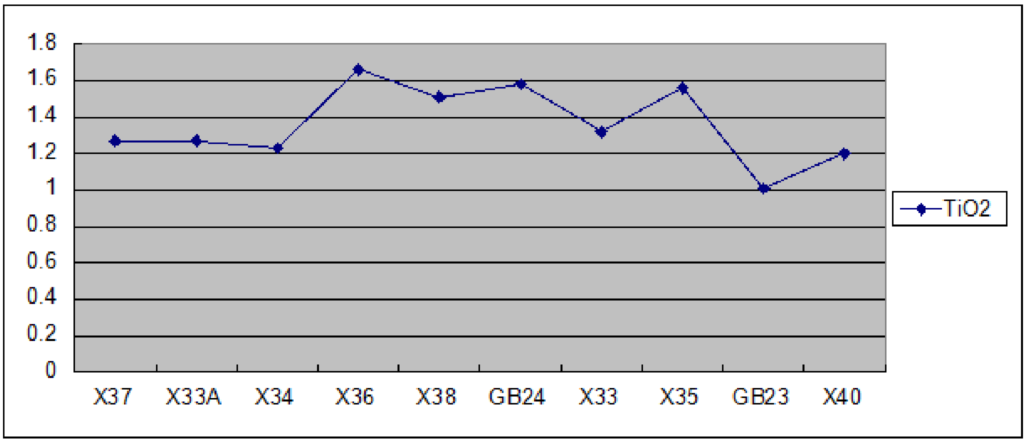


Fig 11: Plot showing the concentration of TiO_2

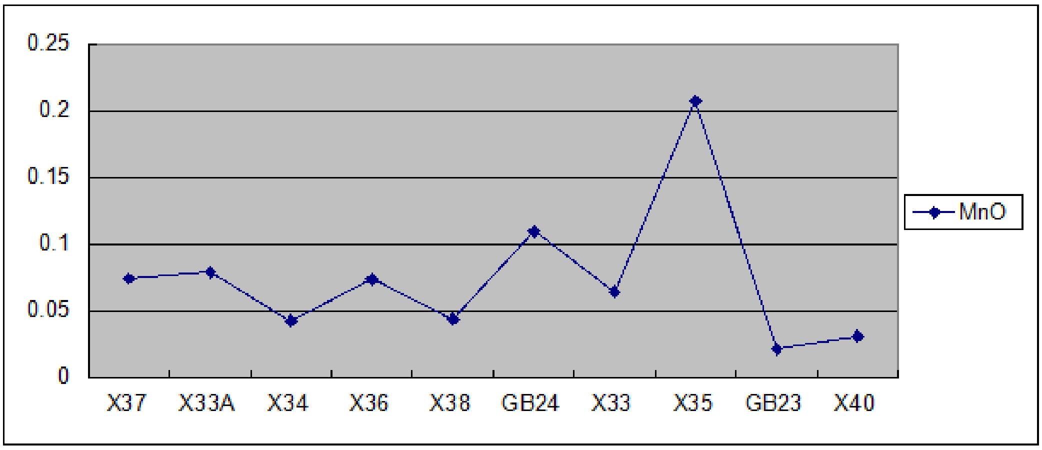


Fig 12: Plot showing the concentration of MnO

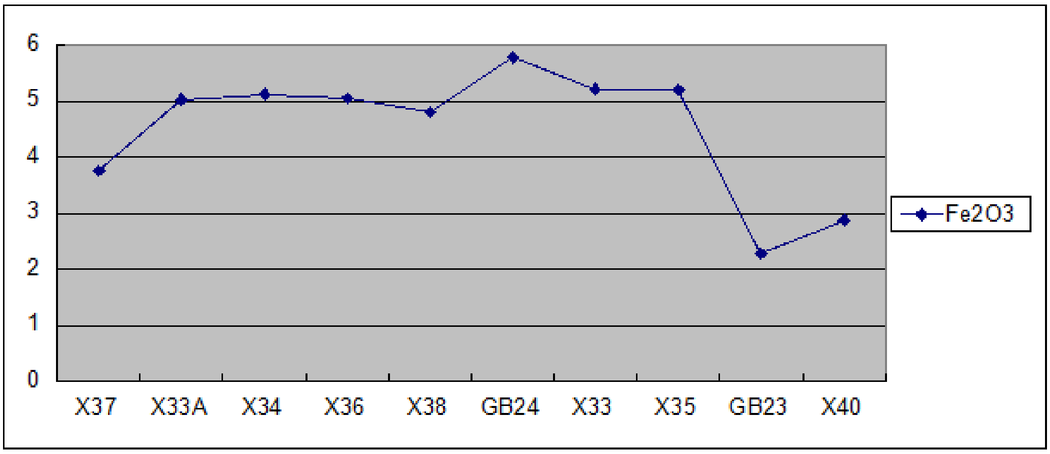


Fig 13: Plot showing the concentration of Fe_2O_3

V. CONCLUSION

The depositional environment of the Yolde Formation exposed around Gabukka village of the Gongola sub-basin, Northern Benue Trough was studied. The stream channels were followed and samples of sandstones and mudstones were collected and analyzed for major oxides using XRF. The results obtained from these analysis shows that the samples are highly rich in Cl, SiO_2, and $Al_2O_3$and poorly rich in MgO, MnO element. Geochemical results show that the average value of Chlorine and silica is far higher than the average values of the other oxides. Silica enrichment is a measure of sandstone maturity and is a reflection of the duration and intensity of weathering and destruction of other minerals during transportation. Major oxide ratios reveals passive Continental margin, quartz arenite, sublith-arenite, lith-arenite and Fe-rich sandstones derived from pre-existing igneous rock and the sediments had mixed marine and terrigenous source input deposited mainly in humid climatic condition.

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