INORGANIC GEOCHEMISTRY AS A TOOL FOR SEDIMENTOLOGICAL STUDEIS: A CASE STUDY OF A SECTION OF GN-WELL, NORTHERN DEPOBELT, NIGER DELTA BASIN

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Abstract: Fifty (50) ditch cutting samples were collected from GN-well located in the Northern Depobelt, Niger Delta Basin at depth interval of 110ft to 860ft. Sedimentological investigation revealed the lithology, colour, grain shape, grain size, degree of sorting and mineralogy of the sediments. The samples are predominantly sands. Geochemical analysis was performed on eight (8) selected samples by employing the X-Ray Fluorescence (XRF) spectrometry. Major oxides observed were SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, P_2O_5, K_2O, MnO, MgO, Na_2O and trace elements recorded were Ba, Cu, Cr, Ni, Zn, Co, Th, Pb, Sc, La, V, U. Provenance, Paleo-redox condition, tectonic setting and sandstone class of the sediments were established. The trace elemental ratios of V/Cr and U/Th showed an oxic environment of deposition. Bivariate plot of Ni versus TiO_2 and trace elemental ratios of Th/Sc, Th/Co, Cr/Th revealed that the sediments source was felsic in nature. The plot of K_2O/Na_2O versus SiO_2 and Log (K_2O/Na_2O) versus Log (SiO_2/Al_2O_3) fell majorly within the passive margin zone. Pettijohn and Herron classification schemes were applied to classify the sands. The aforementioned classification schemes pointed in the direction of Fe-sandstones and sublithic arenites.

Keywords: Chemostratigraphy, Environment, Lithofacies, Provenance, Sandstone, Tectonic setting

Introduction

The Niger Delta is the most consequential hydrocarbon province on the West African Continental Margin (Ekweozor and Daukoru, 1984). It is part of the world's most productive oil producing tertiary deltas. This oil-bearing nature has made the basin a subject of consistent, ceaseless and proper geological investigations for many years, both for academic and economic purposes. Intensive exploration and exploitation in the basin have been going on since the early 1960s due to the discovery of oil in large quantities in the Oloibiri-1 well in 1956 (Nwajide and Reijers, 1996). A good number of important hydrocarbon reservoirs in the Niger Delta Basin are located in areas of structural and stratigraphic complexity (Short and Stauble, 1967). Most fields consist of single reservoirs containing oil and gas of different composition. Important amounts of the world's hydrocarbon reservoirs are found in sequences with bad stratigraphic control. Correlations are sometimes made based on only lithological and/or petrophysical properties. To enhance the stratigraphy of such sections, heavy mineral analyses and isotopic techniques are often used. Petroleum discovery has been highly dependent on biostratigraphy, which relies on available fossil data. However, the limitation of biostratigraphy is that where the organic matter is not preserved, there would be no fossil data to depend on. And hence, the devising of the use of the inorganic elemental concentrations of the well samples, which are not subject to decay. Chemostratigraphy is the characterization and correlation of strata from the changes of the bulk inorganic geochemical or elemental composition and signatures of sedimentary rocks (Ighodaro *et al.*, 2020). The work of Igbinigie and Ogbamikhumi (2022) discussed in details the application of inorganic geochemistry in characterizing Leuma Field Sediments, Coastal Depobelt, Niger Delta Basin.

This study applies variations in inorganic elemental geochemical values to determine the tectonic setting, provenance, sandstone class and paleo-redox condition of the sediments. Inorganic geochemistry was used to have reliable information about the examined well.

Geologic setting

The Niger Delta Basin, which is among the world's most prolific Tertiary Deltas occupies the Gulf of Guinea continental margin in the equatorial West Africa between Latitude 3 and 6ºN and Longitude 5 and 8ºE (Selley, 1997). It is an extensional rift basin and is among the biggest sub-aerial basins in Africa. Three depositional cycles have taken place in the coastal sedimentary basin of Nigeria. In the Middle Cretaceous, there was a marine invasion, which was followed by a minor folding period that ended in Santonian time. The second was marked by the development of the Proto-Niger Delta in the Late Cretaceous and culminated in a significant Paleocene Sea transgression. During the third cycle, which covered the Eocene to Recent era, the major Niger Delta kept growing Burke (1972). The stratigraphy, sedimentology, structural configuration and paleo environment in which the reservoir rocks built up have been researched by many workers. These include (Selley, 1997; Doust and Omatsola, 1990; Evamy *et al.*, 1978; Weber and Daukoru, 1975; Short and Stauble, 1967).

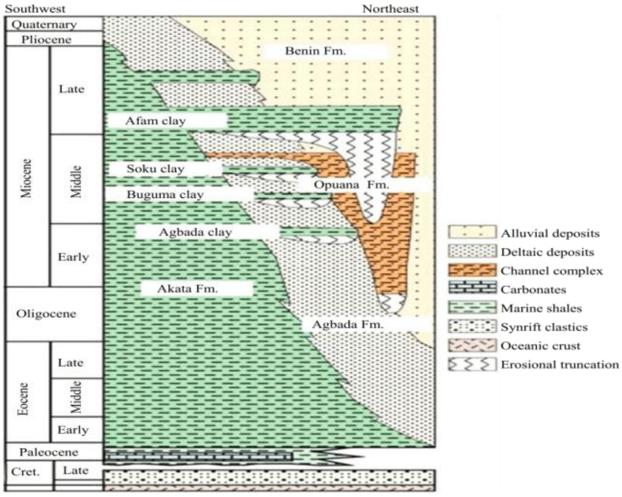


Figure 1: Lithostratigraphic units of the Niger Delta (Doust and Omatsola, 1990).

A subsurface extension of the West African Shield called the Benin Flank surrounds the Niger Delta on its north-west side. The Calabar Flank, which is located south of the Oban Masif, forms the eastern boundary of the basin (Murat, 1972). Three vertical lithofacies: an upper delta top facies, a middle delta front lithofacies, and a lower pro-delta lithofacies are typically visible in well sections through the Niger Delta (Figure 1). These lithostratigraphic units correspond respectively to the Benin Formation (Oligocene-Recent), Agbada Formation (Eocene-Recent) and Akata Formation (Paleocene-Recent) of Short and Stauble (1967). The map showing the location of GN-well is shown in figure 2

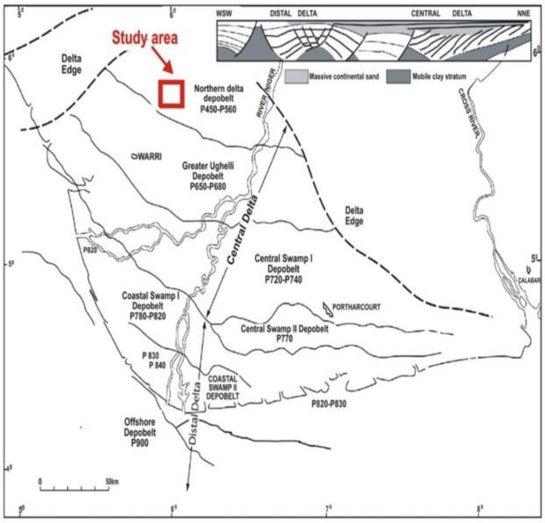


Figure 2: Map showing the location of GN well. (Doust and Omatsola, 1990).

Materials and Methods

Ditch cutting samples from GN-well were analyzed using X-ray fluorescence spectroscopy (XRF). Eight samples comprising of sands were selected for this study using the aforementioned method. The results derived from the analysis were used for the geochemical characterization of the well. The analytical technique generated results for ten (10) major elements, recorded as oxide percent by weight (SiO_2, Al_2O_3, Fe_2O_3, MgO, MnO, CaO, TiO_2, Na_2O, K_2O and P_2O_5). Results for twelve (12) trace element (Ba, Cu, Cr, Ni, Zn, Co, Th, Pb, Sc, La, V, U) reported in ppm were also recorded. Paleo-oxygenation studies, provenance studies, tectonic setting studies and sandstone classification was done with these elements or ratios of elements (Ratcliffe *et al*., 2006; Jones and Manning, 1994). These key elements and element ratios, termed key indices, were used for inorganic geochemical characterization.

Procedure for XRF analysis

The samples were crushed using agate mortar after being oven dried at 105ºC for one day. The samples were mixed using sufficient amount of distilled water and left to settle for one day. For this analysis, dilution method was used (the samples and standards were homogeneously mixed with analytical grade boric acid, in a 0.6 g o 5.4 g ratio). Stainless steel die was then used to compress the homogeneous mixture to form circular disks dilution method was used, where the samples as well as the standards was homogenously mixed with analytical grade boric acid, in a 0.6 g to 5.4 g ratio. The homogenized mixture was compressed in stainless steel die to form circular disks of 0.5 cm thickness and 4cm diameter.

Results and Discussions

Lithofacies description

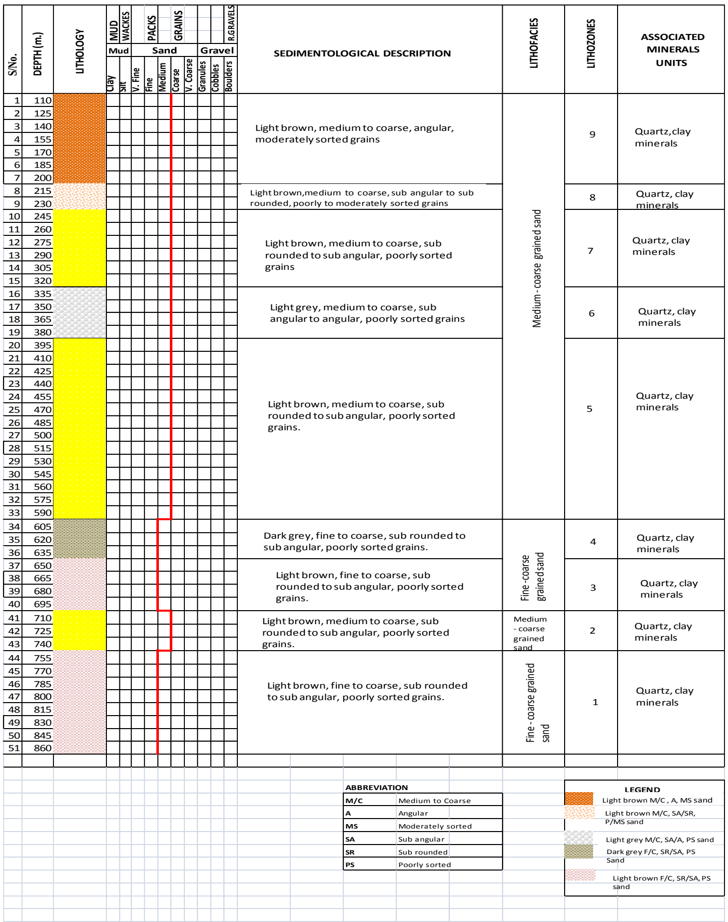
Two lithofacies were delineated, basically by the grain size distribution within the analyzed interval. They are medium–coarse grained sand facies and fine-coarse grained sand facies.

Medium-coarse grained sand facies: Between 110m and 590m, the grain sizes were consistently medium to coarse. The grains were sub-rounded to sub-angular and moderately to poorly sorted. Despite several color changes within this section, ranging from light brown to light grey and dark grey, the uniformity in grain size distinguished this section from the underlying section (605m to 95m), which had fine to coarse grains. This observation defined the Medium-Coarse Grained Sand Lithofacies. Additionally, the interval from 710m to 740m was also classified into the Medium-Coarse Grained Sand Lithofacies due to the similar grain size distribution.

Fine-medium grained sand facies: This occurred within intervals 605m-695m and 755m-860m. It is observed that grain sizes within these intervals range from fine to coarse, which differentiate them from the other intervals that range from medium to coarse grains.

The litholog of GN well is shown in table 1

Table 1: Litholgic Log of GN well



S/No.	DEPTH (m.)	LITHOLOGY	SEDIMENTOLOGICAL DESCRIPTION	LITHOFACIES	LITHOZONES	ASSOCIATED MINERALS UNITS
1	110	🟧	Light brown, medium to coarse, angular, moderately sorted grains	Medium - coarse grained sand	9	Quartz,clay minerals
2	125	🟧				
3	140	🟧				
4	155	🟧				
5	170	🟧				
6	185	🟧				
7	200	🟧				
8	215	░	Light brown,medium to coarse, sub angular to sub rounded, poorly to moderately sorted grains		8	Quartz, clay minerals
9	230	░				
10	245	🟨	Light brown, medium to coarse, sub rounded to sub angular, poorly sorted grains		7	Quartz, clay minerals
11	260	🟨				
12	275	🟨				
13	290	🟨				
14	305	🟨				
15	320	🟨				
16	335	▒	Light grey, medium to coarse, sub angular to angular, poorly sorted grains		6	Quartz, clay minerals
17	350	▒				
18	365	▒				
19	380	▒				
20	395	🟨	Light brown, medium to coarse, sub rounded to sub angular, poorly sorted grains.		5	Quartz, clay minerals
21	410	🟨				
22	425	🟨				
23	440	🟨				
24	455	🟨				
25	470	🟨				
26	485	🟨				
27	500	🟨				
28	515	🟨				
29	530	🟨				
30	545	🟨				
31	560	🟨				
32	575	🟨				
33	590	🟨				
34	605	▩	Dark grey, fine to coarse, sub rounded to sub angular, poorly sorted grains.	Fine - coarse grained sand	4	Quartz, clay minerals
35	620	▩				
36	635	▩				
37	650	▦	Light brown, fine to coarse, sub rounded to sub angular, poorly sorted grains.		3	Quartz, clay minerals
38	665	▦				
39	680	▦				
40	695	▦				
41	710	🟨	Light brown, medium to coarse, sub rounded to sub angular, poorly sorted grains.	Medium - coarse grained sand	2	Quartz, clay minerals
42	725	🟨				
43	740	🟨				
44	755	▦	Light brown, fine to coarse, sub rounded to sub angular, poorly sorted grains.	Fine - coarse grained sand	1	Quartz, clay minerals
45	770	▦				
46	785	▦				
47	800	▦				
48	815	▦				
49	830	▦				
50	845	▦				
51	860	▦				

ABBREVIATION

M/C	Medium to Coarse
A	Angular
MS	Moderately sorted
SA	Sub angular
SR	Sub rounded
PS	Poorly sorted

LEGEND

🟧	Light brown M/C , A, MS sand
░	Light brown M/C, SA/SR, P/MS sand
▒	Light grey M/C, SA/A, PS sand
▩	Dark grey F/C, SR/SA, PS Sand
▦	Light brown F/C, SR/SA, PS sand

Tables 2 and 3 show the results of geochemical investigation. Table 2 display major element data for GN-well while table

3 display trace element data for GN-well. The results were used to determine the sediments' provenance, tectonic setting, paleo-redox condition and sandstone classification.

Table 2: Major oxides result (%)

SAMPLE NUMBER	***LITHOLOGY***	***SAMPLE INTERVAL***	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	P_2O_5	K_2O	MnO	MgO	Na_2O
1	Sands	110-125	90.30	3.95	3.50	0.20	0.15	0.02	0.34	0.05	0.14	0.38
2	Sands	215-230	89.70	3.27	3.06	0.20	0.18	0.09	0.30	0.07	0.17	0.49
3	Sands	320-335	91.70	2.25	2.98	0.20	0.20	0.07	1.25	0.04	0.14	0.70
4	Sands	425-440	91.25	2.50	2.70	0.18	0.16	0.07	0.37	0.07	0.19	0.90
5	Sands	530-545	88.20	3.45	4.68	0.15	0.14	0.06	1.40	0.07	0.21	0.75
6	Sands	635-650	90.25	2.53	3.00	0.20	0.17	0.05	0.33	0.04	0.19	0.85
7	Sands	740-755	90.00	2.70	2.60	0.19	0.16	0.06	0.37	0.03	0.19	0.95
8	Sands	845-860	89.50	4.45	3.68	0.15	0.17	0.07	1.50	0.08	0.31	0.76

As shown in table 2, the percentage composition of SiO_2 is far higher than the percentage composition of the other oxides for all samples analyzed. For instance, the SiO_2 content vary between 88.20wt.% and 91.70wt.% in GN-well with an average of 90.11wt.%. Silica content is a function of the nature and composition of the source area. It is also a measure of sandstone maturity, and is a reflection of the duration and intensity of weathering and destruction of other minerals during transportation (Lindsey, 1999). The value of Al_2O_3 content in GN-well vary between 2.25wt.% and 4.45wt.% with an average value of 3.14wt%. The value of Fe_2O_3 content vary between 2.60wt.% and.68 wt.% with an average of 3.28wt.%. The content of TiO_2 vary between 0.15wt.% and 0.20wt.% with an average of 0.18wt.%. CaO value vary between 0.14wt.% and 0.20wt.% with an average value of 0.17wt.%. P_2O_5 vary between 0.02wt.% and 0.09wt.% with an average of 0.06wt.%. K_2O vary between 0.30wt.% and 1.50wt.% with an average of 0.73wt.%. MnO vary between 0.03wt.% and 0.08wt.% with an average of 0.06wt.%. MgO vary between 0.14wt.% and 0.31wt.% with an average of 0.19wt.%. Na_2O vary between 0.38wt.% and 0.95wt.% with an average of 0.72wt.% in GN-well.

Table 3: Trace elements results (ppm)

SAMPLE NUMBER	**LITHOLOGY**	**SAMPLE INTERVAL**	**Ba**	**Cu**	**Cr**	**Ni**	**Zn**	**Co**	**Th**	**Pb**	**Sc**	**La**	**V**	**U**
1	Sands	110-125	588.40	22.22	35.20	17.60	40.45	14.15	4.28	24.13	2.8	0.64	17.00	0.90
2	Sands	215-230	580	23.32	40.20	19.60	45.25	3.40	3.17	20.35	3.45	0.78	18.5	0.85
3	Sands	320-335	586.50	25.32	40.70	18.65	50.25	3.15	3.13	20.24	2.44	0.52	16.5	0.65
4	Sands	425-440	954.50	45.32	47.70	30.65	51.25	8.50	7.45	40.45	6.45	0.35	35.50	0.95
5	Sands	530-545	788.50	33.32	38.70	20.65	45.25	5.15	4.43	30.24	1.45	15	20.50	0.85
6	Sands	635-650	960.50	45.32	50.70	35.65	60.25	7.50	8.45	45.45	7.45	0.49	30.50	0.86
7	Sands	740-755	850.50	50.32	45.70	42.65	55.25	10.50	8.45	45.45	8.45	0.50	35.50	0.90
8	Sands	845-860	779.55	43.32	42.70	21.65	47.25	6.15	5.43	35.24	1.49	120	23.50	0.90

The geochemical attitude of trace elements during sedimentary processes has often been applied to determine paleo-environmental conditions of deposition (Algeo and Maynard, 2004; Warning and Brumsack, 2000; Calvert and Pedersen, 1993; Brumsack, 1989). Trace element abundances in sedimentary rocks have added immeasurably to our knowledge of crustal evolution with rare earth element (REE) patterns useful in determining provenance (Ganai and Rashid, 2015). Trace elements are usually considered to be a vital part of the tectonic setting due to their really short residence times in freshwater or seawater and their distinctive behavior during fractional crystallization, weathering and recycling (Taylor & McLennan, 1985). Vanadium (V) is a redox-sensitive element that is enriched in sediments underlying anoxic or near-anoxic waters (Calvert and Pedersen, 1993). Kimura and Watanabe (2001), proposed that the enrichment degree is best expressed as the V/Sc ratio. *Dymond et al., 1992* identified Barium (Ba) as a factor for biotic paleo productivity in the oceans due to its strong correlation with settling biogenic matter. High concentration of Ba combined with high palynofloral content infers that most of the Ba provided is in relation with bio-productivity. Krejci-Graf (1972) supplied information on the trace element content of sediments in various depositional environments. Continental sediments that have gone through long periods of sub-aerial weathering typically contain the trace elements titanium and thorium.

Major oxide ratios and trace element ratios are shown in tables 4 and 5 respectively.

Table 4: Major oxide ratios for GN-well

SAMPLE NUMBER	SAMPLE INTERVAL	Na_2O/ TiO_2	K_2O/ Na_2O	Al_2O_3/ TiO_2	Log(SiO_2/Al_2O_3)	Log (K_2O/ Na_2O)	Log (Fe_2O_3/ K_2O)	Log (Na_2O / K_2O)	Tio_2 / Ni	Log (SiO_2/Al_2O_3)	SiO_2/Al_2O_3
Sample 1	110-125	1.9	0.89	19.75	1.36	-0.05	1.01	0.05	0.011	1.36	22.86
Sample 2	215-230	2.45	0.61	16.35	1.44	-0.21	1.01	0.21	0.010	1.44	27.43
Sample 3	320-335	3.5	1.79	11.25	1.61	0.25	0.37	-0.25	0.011	1.61	40.76
Sample 4	425-440	5	0.41	13.89	1.56	-0.39	0.86	0.39	0.006	1.56	36.5
Sample 5	530-545	5	1.87	23.45	1.41	0.27	0.52	-0.27	0.007	1.41	25.57
Sample 6	635-650	4.25	0.39	12.65	1.55	-0.41	0.96	0.41	0.006	1.55	35.67
Sample 7	740-755	5	0.39	14.21	1.52	-0.41	0.85	0.41	0.004	1.52	33.33
Sample 8	845-860	5.07	1.97	29.67	1.30	0.29	0.39	-0.29	0.006	1.30	20.11

Table 5: Trace elements ratio for GN-well

SAMPLE NUMBER	SAMPLE INTERVAL	Ni/Co	Co/Th	La/Sc	Ni/Cr	U/Th	V/Cr	Cu/Zn	Cr/Th	Th/Co	Th/Sc	La/Th
Sample 1	110-125	1.24	3.31	0.23	0.5	0.21	0.48	0.55	8.22	0.30	1.52	0.15
Sample 2	215-230	5.76	1.07	0.23	0.49	0.27	0.46	0.52	12.68	0.93	0.92	0.25
Sample 3	320-335	5.92	1.01	0.21	0.46	0.21	0.41	0.50	13.00	0.99	1.28	0.17
Sample 4	425-440	3.61	1.14	0.05	0.64	0.13	0.74	0.88	6.40	0.88	1.16	0.05
Sample 5	530-545	4.01	1.16	10.34	0.53	0.19	0.53	0.74	8.74	0.86	3.06	3.39
Sample 6	635-650	4.75	0.89	0.07	0.7	0.10	0.60	0.75	6.00	1.13	1.13	0.06
Sample 7	740-755	4.06	1.24	0.06	0.93	0.11	0.78	0.91	5.41	0.80	1.00	0.06
Sample 8	845-860	3.52	1.13	80.54	0.51	0.17	0.55	0.91	7.86	0.88	3.64	22.1

Paleo-redox studies

Redox-sensitive trace element ratios are part of the major indicators extensively used for indicating redox conditions in modern and ancient sedimentary deposits (Calvert and Pederson, 1993).

According to Jones and Manning (1994), an oxic environment is indicated by a U/Th ratio of less than 0.75; a dysoxic environment is indicated by a ratio of 0.75-1.25; and a suboxic to anoxic environment is indicated by a ratio greater than 1.25. The U/Th ratio in GN-well ranges from 0.10-0.27 which indicate oxic environment.

When the ratio of V/Cr is less than 2, it indicates oxic environment, when the ratio is between of 2-4.25, it indicates dysoxic environment and when the ratio is greater than 4.25, it indicates suboxic to anoxic environment. The ratio of V/Cr in GN-well ranges from 0.41-0.75 and this indicates oxic environment.

When the ratio of Ni/Co is less than 5, it indicates oxic environment, when it is between 5-7, it indicates dysoxic environment, and when the ratio is greater than 7, it indicates suboxic to anoxic environment. Ni/Co ratio in GN-well ranges from 1.24-5.92 which indicates oxic environment also. Elemental ratios to evaluate the paleo-redox condition of sediments after Jones and Manning (1994) is shown in table 6 and results for the present study is shown in table 7

Table 6: Elemental ratios to evaluate the paleo-redox condition of sediments after Jones and Manning (1994)

ELEMENT RATIO	OXIC	DYSOXIC	SUBOXIC TO ANOXIC
U/Th	<0.75	0.75-1.25	>1.25
V/Cr	<2	2-4.25	>4.25
Ni/Co	<5	5-7	>7

Table 7: U/Th, V/Cr and Ni/Co ratios for GN-well for the determination of Paleo-redox condition of deposition

SAMPLE NUMBER	U/Th	V/Cr	Ni/Co
Sample 1	0.21	0.48	1.24
Sample 2	0.27	0.46	5.76
Sample 3	0.21	0.41	5.92
Sample 4	0.13	0.74	3.61
Sample 5	0.19	0.53	4.01
Sample 6	0.10	0.60	4.75
Sample 7	0.11	0.78	4.06
Sample 8	0.17	0.55	3.52

Provenance Studies

The concept of Floyd *et al*. (1989) was adopted to determine the origin of the sediments penetrated by GN-well. TiO_2 versus Ni bivariate was used and it revealed that the source of the sediments penetrated by GN-well were predominantly acidic in nature as shown in figure 3

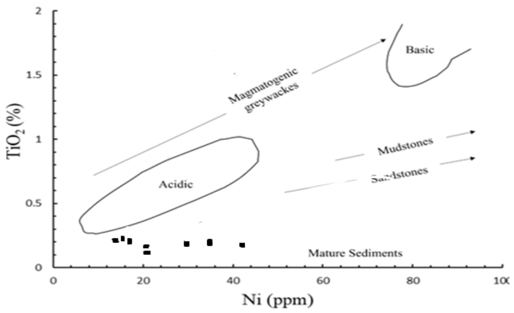


Figure 3: TiO_2 versus Ni bivariate of samples (After Floyd *et al*. 1989)

Table 8: Range of Elemental Ratios of GN-well compared to the Ratios in similar fractions derived from felsic and mafic rocks. After Cullers (1994) (2000), Taylor and McLennan (1985).

ELEMENTAL RATIO	GN-WELL RANGE	RANGE FOR FELSIC ROCKS	RANGE FOR MAFIC ROCKS
Th/Sc	0.92-3.64	0.84-20.5	0.05-0.22
Th/Co	0.30-1.13	0.67-19.4	0.04-1.40
Cr/Th	5.41-13.00	4.0-15.0	25-100

Table 8 shows the range of elemental ratios of GN-well compared to the ratios in similar fractions derived from felsic and mafic rocks Cullers (1994) (2000), Taylor and McLennan (1985).

In GN-well, Thorium/Scandium (Th/Sc) range from 0.92-3.64, Thorium/Cobalt (Th/Co) range from 0.30-1.13 and Chromium/Thorium (Cr/Th) range from 5.41-13.00. As prescribed by Taylor and McLennan (1985), and Cullers (1994), (2000), comparing the values recorded above with the range for felsic and mafic rocks, it was be concluded that the sediments recovered from GN-well were transported from felsic source rocks.

Tectonic Setting

The processes involved in plate tectonics give sediments specific geochemical characteristics in two different ways. Firstly, various tectonic environments exhibit various provenance characteristics, and secondly, they are distinguished by different sedimentary processes. Sedimentary basins can be categorized into the following tectonic settings: active continental margin, passive continental margin, oceanic island-arc, collisional setting and continental island-arc.

The concept of Roser and Korsch (1986) was applied to determine the tectonic setting of GN-well. Roser and Korsch (1986) plotted K_2O/Na_2O vs SiO_2 to determine the provenance of sediments. The recognized tectonic settings on the K_2O/Na_2O versus SiO_2 discrimination diagram of Roser and Korsch (1986) are: the passive continental margin (PCM), active continental margin (ACM) and oceanic island arc (OIA). When utilized for the samples recovered from GN-well, they fell majorly in the passive continental margin zone, which infer that the tectonic setting for GN-well facies is in the passive continental margin (figure 4)

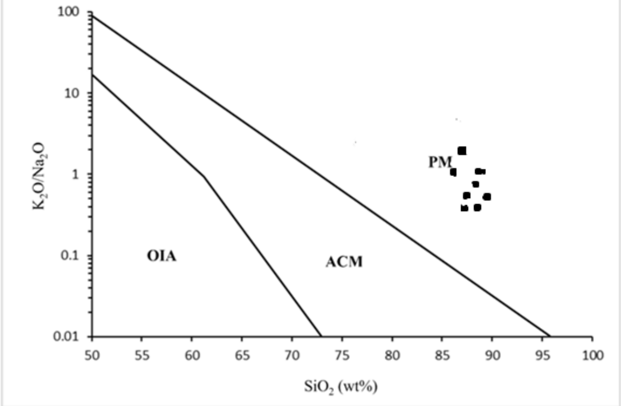


Figure 4: Tectonic discrimination plot for Samples. After Roser and Korsch (1986). PM: passive margin, ACM: active continental margin and OIA: oceanic island arc.

Log (K_2O/Na_2O) versus Log (SiO_2/Al_2O_3) was also used to determine the tectonic setting as postulated by Maynard *et al*. (1982). The recognized tectonic settings on the Log (K_2O/Na_2O) ratio versus Log (SiO_2/Al_2O_3) ratio discrimination diagram of Maynard *et al*. (1982) are: A1 - arc setting and andesitic detritus; A2 - evolved arc setting, felsic pluton detritus; ACM - Active continental margin; PM - passive margin. When applied for the samples of GN-well, they plotted majorly in the passive margin zone which infers that the tectonic setting for GN-well facies is in the passive continental margin (Figure 5)

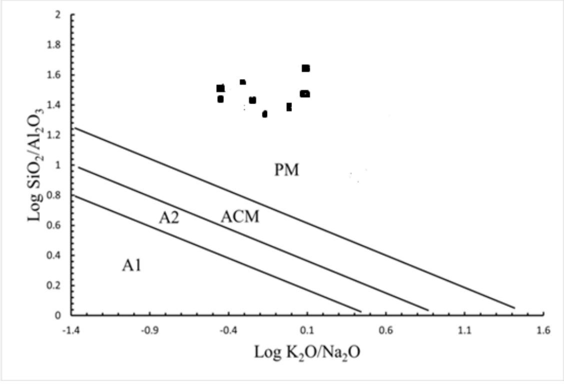


Figure 5: Log (K_2O/Na_2O) ratio versus Log ($SiO_2/Al2O_3$) ratio tectonic discrimination diagram of samples. After Maynard *et al.* (1982), Al - arc setting and andesitic detritus, A2 - evolved arc setting, felsic pluton detritus, ACM - Active continental margin, PM - Passive Continental Margin.

Sandstone Classification

Sandstone classification can provide a good knowledge of its origin, Boggs (1967). The classification of sandstone also impacts the understanding and interpretation of the paleo-geography and tectonic background of the provenance.

Herron (1988) postulated a classification scheme in which Log (SiO_2/Al_2O_3) is plotted against Log (Fe_2O_3/K_2O). By plotting Log (SiO_2/Al_2O_3) against Log (Fe_2O_3/K_2O) in this work, the sandstone facies of GN-well plotted mainly in Fe-sand domain and sublitharenite domain (Figure 6).

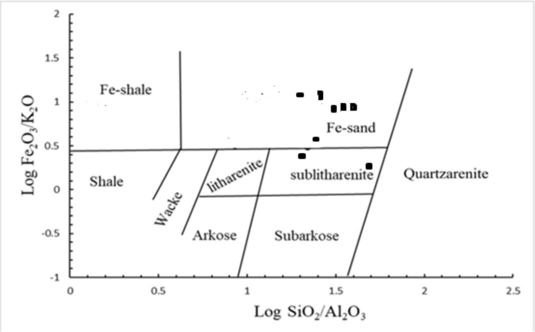


Figure 6: Chemical Classification of the sandstone. After Herron (1988)

Making use of Pettijohn's postulation in this study, the sandstones penetrated by GN-well plotted mainly in the sublithic arenite domain as shown in Figure 7

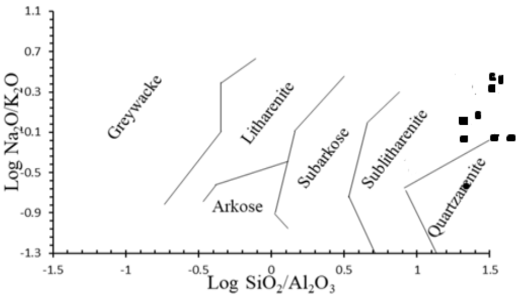


Figure 7: Classification of samples sandstone facies based on Log (SiO_2/Al_2O_3) vs. Log (Na_2O/K_2O). After Pettijohn (1972).

Conclusion

Sedimentological analysis showed that the studied section of GN-well comprised of mainly sands. Geochemical characterization using major oxides and trace elemental ratio inferred that the sediments of GN-well were derived from felsic rock and in a passive margin zone. In addition, the trace elemental ratio of U/Th and V/Cr showed that the sediments of GN-well were deposited in an oxic environment. The sandstones classification schemes used in this work characterized the sediments as sublitharenite, Fe-rich sand and quartzarenite.

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