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SEDIMENTOLOGICAL AND COMPOSITIONAL STUDIES OF ITORI WELL, EASTERN DAHOMEY BASIN, SOUTHWESTERN NIGERIA.

Nton, M.E[1], *Adesanoye, T.P[1], Omotayo, J.O[1] and Omietimi, E.J[2]

[1]Department of Geology, University of Ibadan, Ibadan, Nigeria

[2]Department of Geology, University of Pretoria, South Africa

Subtheme

Basin Analysis and Integrated Reservoir modelling for Petroleum Development and Production

Outline

- Introduction
- Aims and Objectives
- Outline of Geology and Stratigraphy
- Materials and Methods
- Results and Discussion
- Summary and Conclusion
- Acknowledgments

Introduction

The Dahomey Basin is an extensive sedimentary basin on the continental margin of the Gulf of Guinea which extends from the Volta Delta in Ghana in the west to the Okitipupa Ridge in Nigeria in the east (Whiteman, 1982) (fig1), its distance is about 440km, and its width as measured from the northern onshore margin in Benin (Dahomey) to the 3,000m bathymetric contour is about 224km (Whiteman, 1982).

The area of the onshore part of this Basin in all four countries involved (Ghana, Togo, Benin and Nigeria) up to the shelf break, probably does not exceed 30,400sq.km

The basin contains extensive wedge of Cretaceous to Recent sediments up to 3000m, which thickens from the onshore margin .

The well , is located within the eastern Dahomey Basin, Southwestern Nigeria and lies within Latitude 7° 6′ 0″ N and Longitude3° 25 ′ 60 ″.

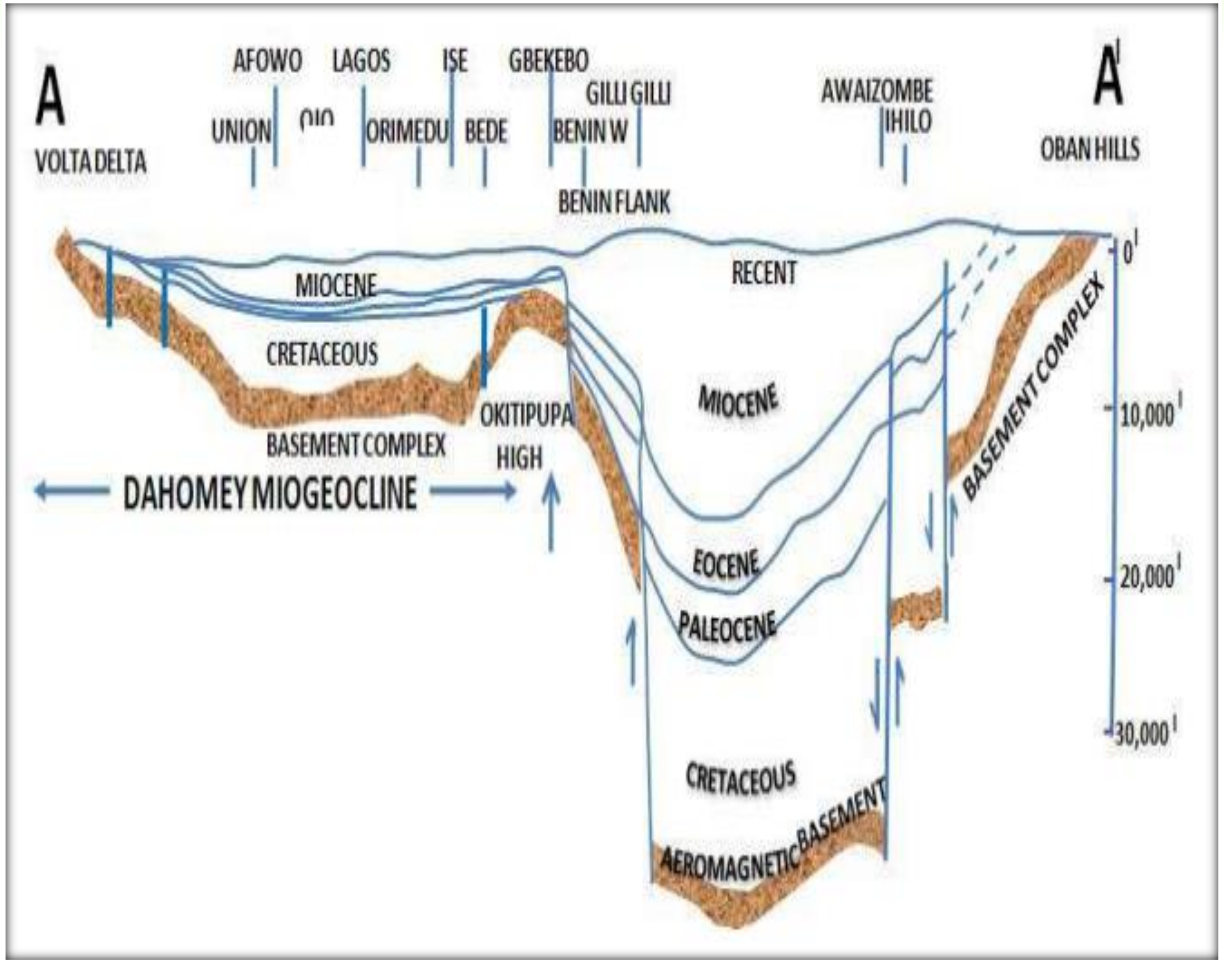

Fig. 1 East-West Geological section showing position, extent and sediment thickness variations in the onshore Dahomey Basin and the upper part of the Niger Delta (After Whiteman, 1982).

Aims and objectives

Aims:

To evaluate the petrography and inorganic geochemical characteristics of the sediments from Itori well, within the eastern Dahomey Basin, Southwestern Nigeria.

Objectives

i. Determination of the different lithofacies as penetrated by Itori well

ii. Determination of the mineralogical composition of the sediments

iii. Ascertaining the provenance and paleo-depositional environment,

iv. Deduction of tectonic history and weathering conditions.

v. Ascertaining the paleo-redox and paleo –productivity of sediments

Outline of Geology and Stratigraphy

- Abeokuta Group: Late Cretaceous –Tertiary
- Ewekoro Formation: Paleocene
- Akinbo Formation: Late Paleocene - Early Eocene
- Oshosun Formation : Eocene
- Ilaro Formation: Eocene
- Coastal plain Sands (Benin FM): Oligocene to Recent.

Table 1: Cretaceous and Tertiary Stratigraphy of Nigeria part of Dahomey Basin (Olabode,2006).

AGE		GROUP	FORMATIONS	
QUATERNARY			BENIN (COASTAL PLAIN SANDS)	
TERTIARY	PLIOCENE			
	MIOCENE		ILARO	
	OLIGOCENE			
	EOCENE		OSOSUN	
			AKINBO	
	PALEOCENE		EWEKORO	
CRETACEOUS	MAASTRICHTIAN		ARAROMI	
	CAMPANIAN			
	SANTONIAN			
	CONIACIAN		AFOWO	
	TURONIAN			
	CENOMANIAN			
	ALBIAN		ISE	OKITIPUPA RIDGE (BASEMENT)
	APTIAN			
	BARREMIAN			
	NEOCOMIAN			

Materials and Methods

Materials and Method

Samples

20 samples (depth 55m to 320m)

Samples were described based on lithology, texture, color, sorting and fossil content, among others using a handlens.

Thin Section Petrography

Photomicrograph of both limestone and sandstone were taken

Major Oxides

12 samples using XRF (x ray refraction method)

Trace and Rare Elements

12 samples using icp-ms(Inductively coupled plasma mass spectrometer)

Results and Discussion

Lithological Description

Fig 2,shows the lithologic succession of the study well made up predominantly sandstone which is sub rounded to well rounded, well sorted and fine grained indicating the Abeokuta group (Araromi Formation), overlying the limestone unit which calcareous, greenish and highly fossiliferous.(the Ewekoro Formation)

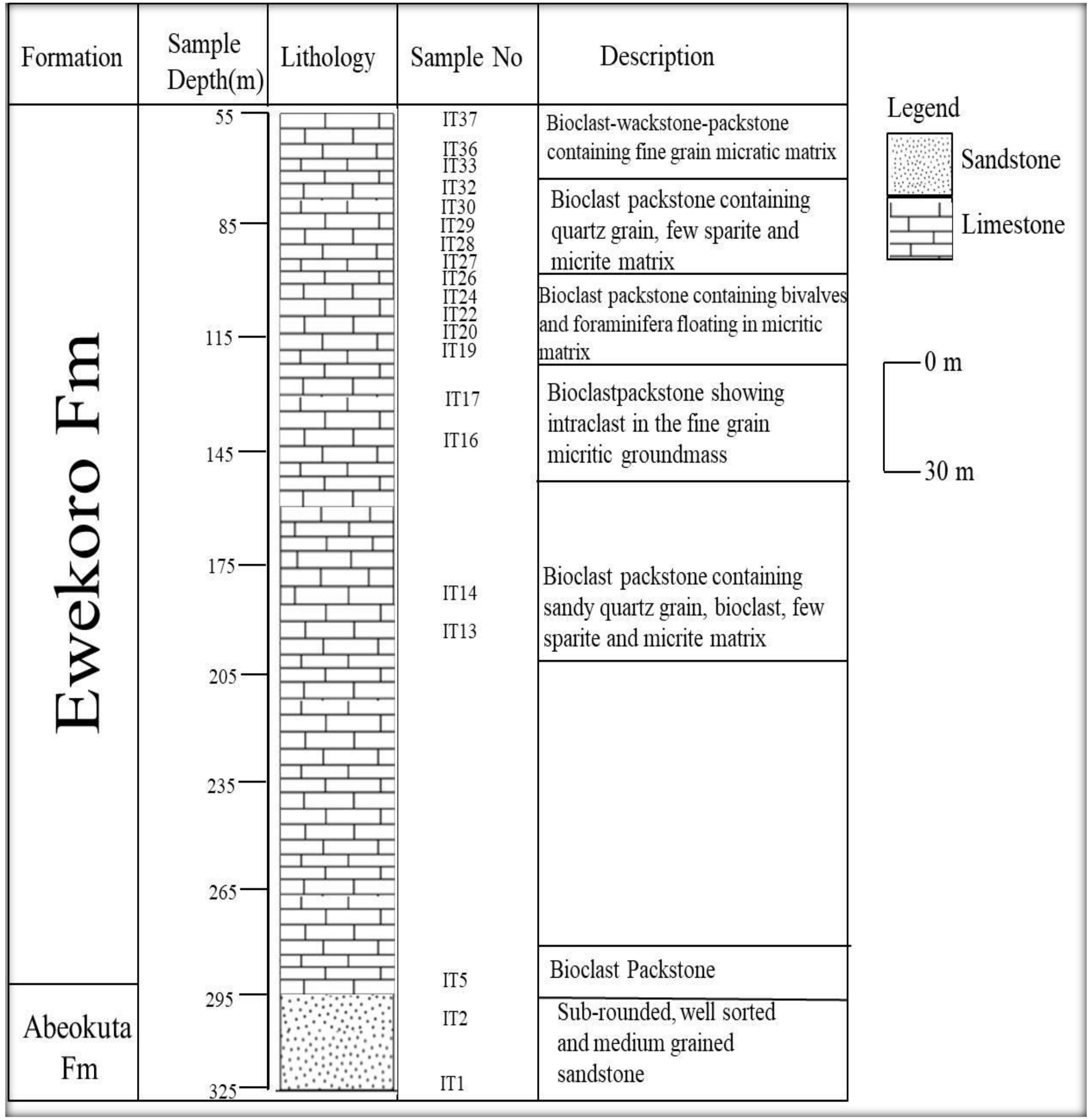

Fig 2: Lithological section of Itori well

Results and Discussion

Result of Sandstone Petrology

The modal analysis shows that the dominant mineral in the sandstone sample is quartz (90-94%) with feldspar having less than (< 3.5%) and rock fragment content less than (< 2%).

Other minor minerals include; Rutile, Garnet and Tourmaline.

Table 2: Relative abundance of the constituents and framework composition of Itori well Sandstone.

Sample no	Formation	Quartz (%)	Feldspar (%)	Rock fragment (%)	Other Minerals present (%)			Framework composition (%)	
					R	G	T	Q	F
IT 1	Abeokuta	93	3	2	1	-	1	94.89	3.06
IT2	Abeokuta	94	2	2	-	1	1	95.91	2.04

R= Rutile T=Tourmaline G = Garnet

Results and Discussion

Thin Section Photographs of Itori Sandstone

- The Feldspars are partly weathered and the rock fragments are mainly that of igneous and metamorphic varieties < 2%. The cementing is silica, with optical continuity with the quartz grains. The quartz grains are more of monocrystalline variety quartz.

- The sandstone sample is sub rounded to well rounded, well sorted and fine grained. fig 3

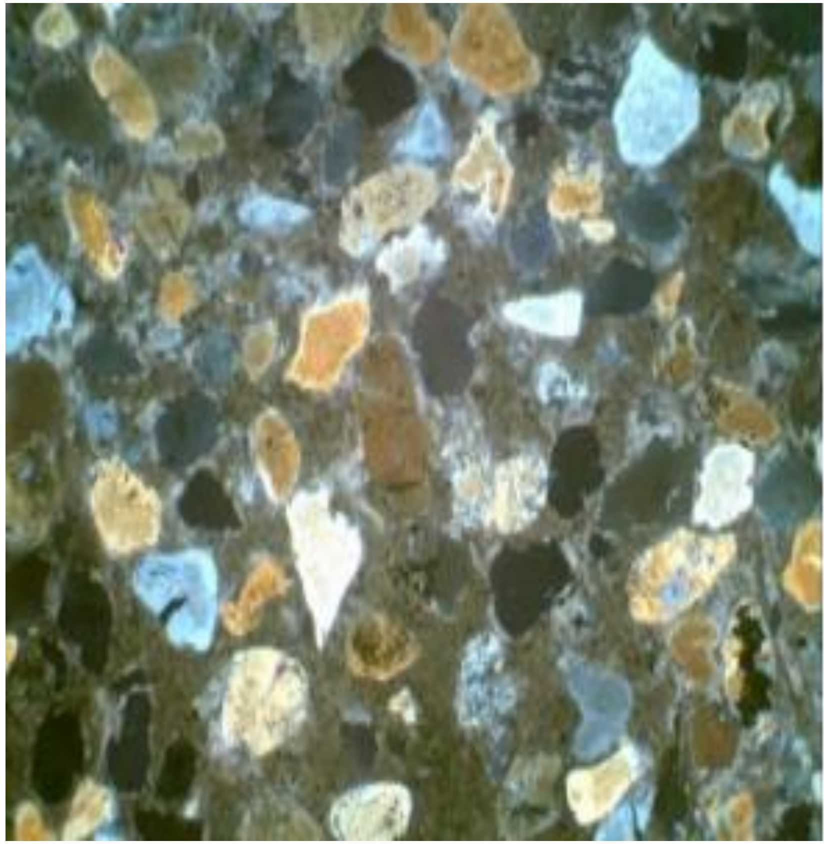

Fig 3: Photomicrograph of Quartz Arenite of the Itori well (IT1) under XPL and PPL characterized by well sorted quartz grain (Mag =40x)

Results and Discussion

Q-F-RF Classification of Sandstone

- Based on the Q-F-RF diagram of Folks (1974), the analyzed sandstone samples were classified as Quartz Arenite (fig.4)

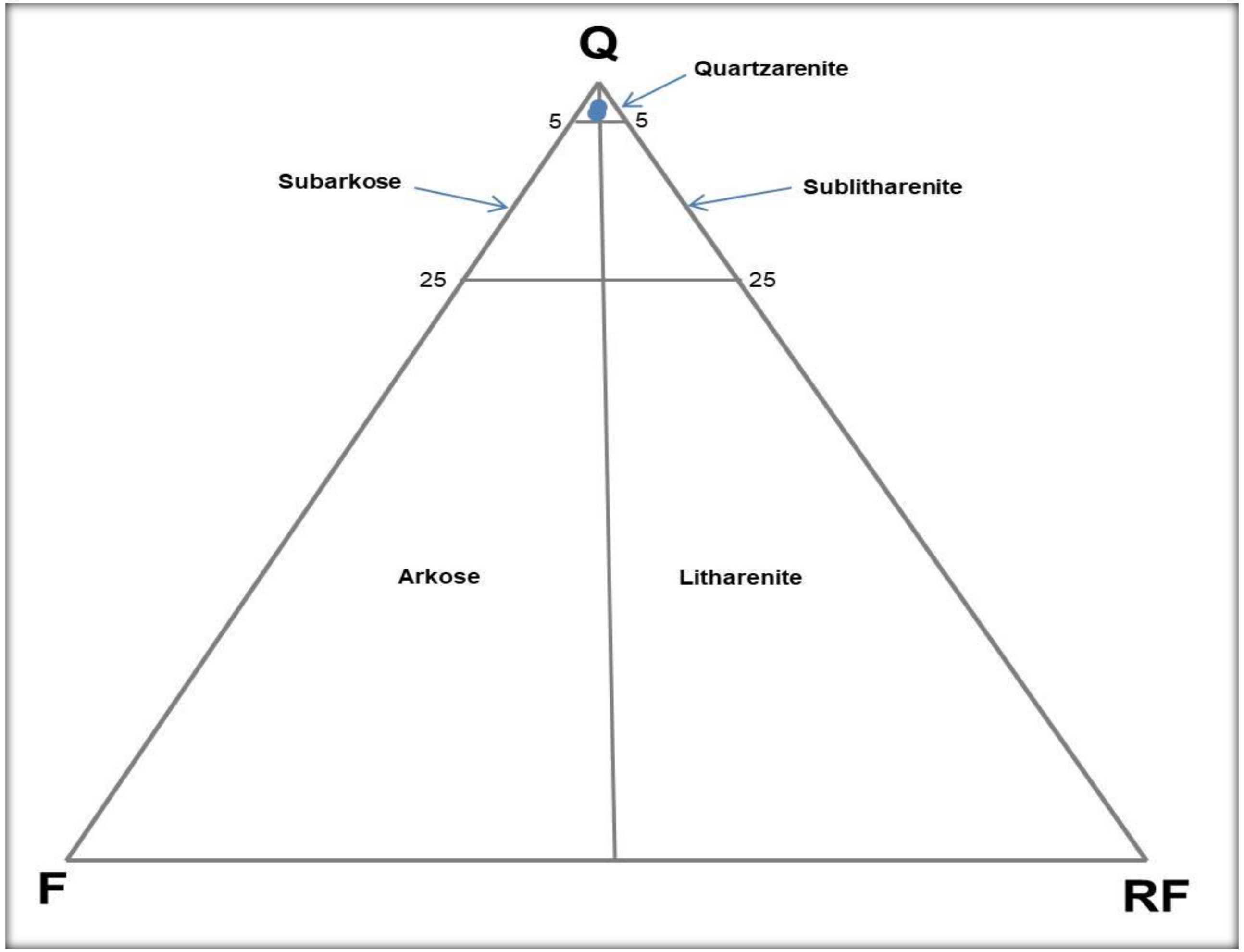

Fig 4: Ternary Diagram for Classification of sandstone based on Framework composition (After: Folk 1974) Note: Q= Quartz, F= Feldspar, RF= Rock Fragment

Results and Discussion

Thin Section Photographs of Itori Limestone

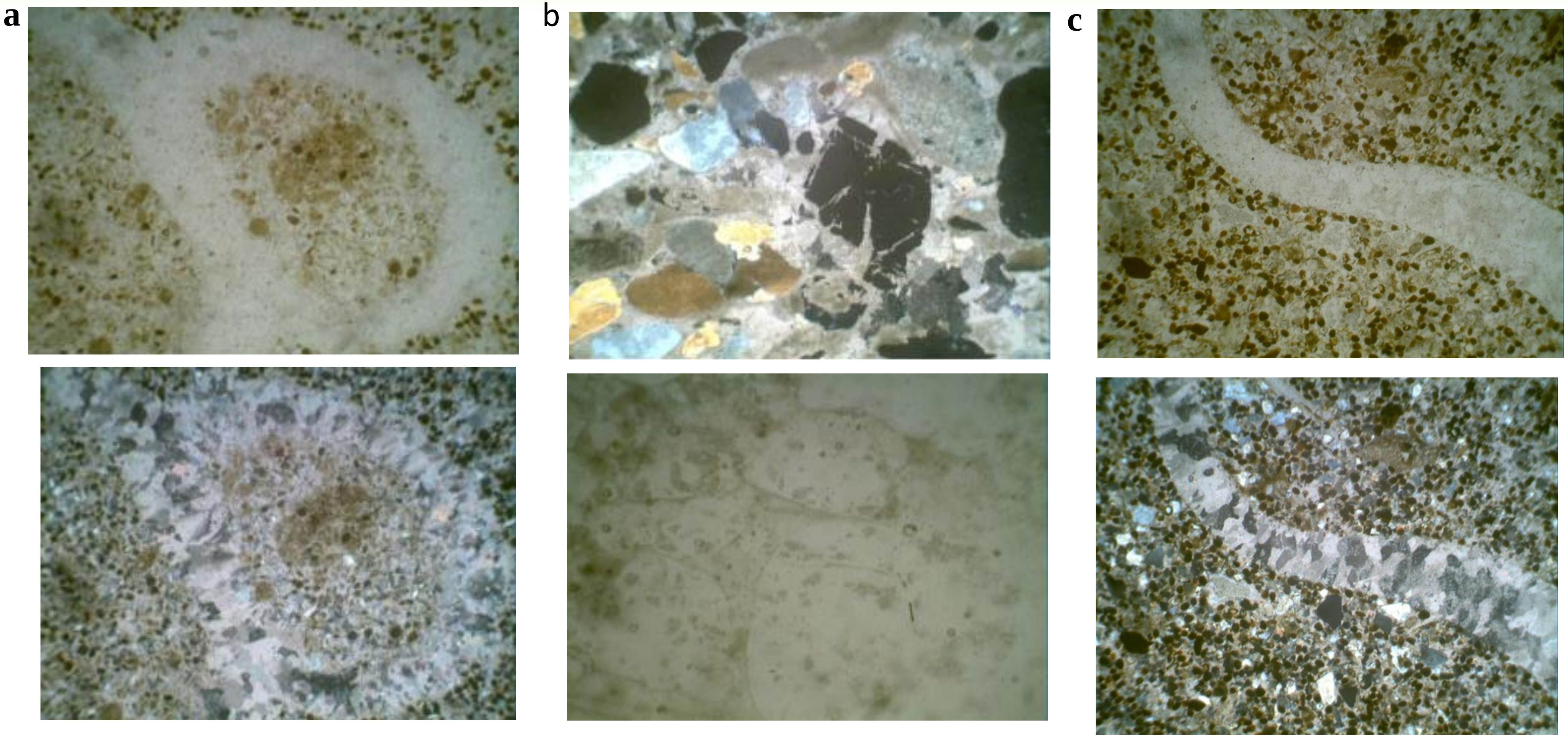

Fig 5: Photomicrograph of the Itori well limestone a) Bioclast packstone containing sandy quartz grain, few sparite and micrite (IT 13)under PPL and XP b) Sandy Bioclast packstone shows gastropod with infilling sparry calcite cement under PPL and XP c) Bioclast packstone showing intra clast in the fine grain micritic groundmass under PPL and XP (IT17).

Results and Discussion

Table 3: Distribution of major oxide concentration (%) in the study well

	IT2	IT5	IT13	IT14	IT16	IT17	IT19	IT22	IT26	IT28	IT 30	IT 32	AVG
Oxides	Sandstones		Limestone										
SiO_2	71.83	33.29	39.18	53.32	51.76	41.35	23.64	43.27	42.65	29.87	22.9	13.03	38.84
Al_2O_3	2.03	3.97	2.56	1.47	0.29	0.22	0.95	0.23	0.49	0.33	0.74	0.31	1.13
MgO	0.36	0.64	1.22	1.49	0.62	0.61	1.62	0.87	1.55	0.55	0.54	0.42	0.87
Na_2O	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
P_2O_5	0.18	0.15	0.23	0.34	0.07	0.08	0.25	0.06	0.07	0.06	0.21	0.14	0.15
Fe_2O_3	1.95	2.4	7.58	12.87	0.58	0.6	1.56	0.74	0.82	0.64	1.06	0.6	2.62
K_2O	0.13	0.18	0.16	0.1	0.01	0.01	0.07	0.01	0.02	0.01	0.02	0.01	0.06
CaO	11.48	31	24.31	12.95	24.94	30.16	38.41	29.19	28.3	37.31	40.42	46.6	29.59
TiO_2	0.18	0.17	0.77	0.26	0.12	0.05	0.06	0.03	0.06	0.02	0.03	0.02	0.15
V_2O_5	<0.01	<0.01	0.04	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
Cr_2O_3	0.01	<0.01	0.03	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
MnO	0.05	0.09	0.08	0.09	0.03	0.03	0.04	0.02	0.02	0.04	0.07	0.05	0.05
NiO	<0,01	<0,01	0.01	<0.01	<0.01	<0,01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
CuO	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ZrO_2	0.13	0.07	0.74	0.15	0.1	0.05	0.03	0.05	0.06	0.03	0.02	0.02	0.12
S	0.52	0.53	0.23	0.04	<0.01	<0.01	0.03	0.23	0.06	0.01	0.01	0.01	0.17
C_3O_4	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0,01	0.01
ZnO	0.01	0.01	0.04	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
SrO	0.06	0.13	0.07	0.04	0.06	0.08	0.15	0.09	0.1	0.09	0.13	0.12	0.09
WO_3	<0,01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
LOI	11.09	27.35	22.75	16.81	21.4	26.7	33.18	25.15	25.77	31.01	33.82	38.64	26.14

Results and Discussion

Table 4: Distribution of trace element concentration (ppm) for the study well

ppm	IT2	IT5	IT13	IT14	IT16	IT17C	IT19	IT22	IT26	IT28	IT30	IT32	Total	AVG
	Sandstones		Limestone											
Sc	2.86	5.79	11.81	5.66	0.76	0.70	2.29	0.65	0.95	0.86	2.13	1.29	35.75	2.97
Co	4.83	3.62	9.64	5.17	0.35	0.39	1.91	1.01	0.94	0.71	2.55	1.34	32.46	2.70
Cu	4.13	6.19	5.54	4.18	2.79	3.89	3.17	3.11	3.72	4.49	4.22	5.22	50.64	4.22
Ni	12.10	12.03	20.14	11.50	2.33	2.29	5.38	4.46	4.29	3.73	8.35	4.65	91.25	7.60
V	15.50	21.33	258.34	121.3	5.04	5.23	18.66	5.53	9.08	8.28	22.48	10.70	501.45	41.78
Zn	46.77	49.09	268.01	60.78	19.36	46.99	30.36	15.42	31.40	26.47	52.60	21.31	668.55	55.8
Cr	23.87	31.82	141.73	52.48	14.52	13.47	25.73	10.82	33.97	17.12	32.52	27.17	425.21	43.0
Zr	27.51	22.09	426.17	86.22	9.76	9.18	11.26	4.65	9.29	6.17	7.67	4.70	624.67	52.05
Cs	0.34	0.70	0.31	0.21	0.07	0.07	0.23	0.08	0.15	0.10	0.18	0.10	2.53	21.0
Hf	0.84	0.55	10.64	2.45	0.28	0.24	0.32	0.13	0.24	0.17	0.22	0.13	16.20	35 .0
Nb	2.17	3.22	7.31	3.11	1.07	1.54	1.12	0.62	1.08	0.58	0.79	0.64	23.24	94 .O
Rb	5.26	10.36	6.26	3.62	1.33	1.31	4.61	1.76	3.03	2.23	3.21	1.74	44.73	73 .0
Sr	141.9	389.38	213.78	126.4	155.63	257.88	543.14	282.95	304.31	330.50	449.03	460.24	3654.83	304.6
Th	1.60	1.92	11.32	3.71	0.59	0.43	1.06	0.49	0.92	0.65	1.57	0.88	25.12	2.09
U	1.06	1.17	2.46	0.87	0.36	0.35	1.96	0.63	0.49	0.32	0.98	0.45	11.11	0.93
Ba	24.95	27.92	36.94	36.91	6.42	5.20	12.14	6.04	8.15	9.50	10.77	7.11	192.03	16.00
Pb	4.76	4.04	17.74	7.39	2.30	1.30	1.62	2.07	2.44	1.59	4.43	2.51	52.19	4.35
P	549.9	550.88	551.88	552.9	553.88	554.88	555.88	556.88	557.88	293.83	977.39	662.32	6918.48	576.5
Li	22.17	53.33	19.18	10.02	3.54	3.01	10.42	2.90	5.74	2.98	6.28	2.89	142.45	11.87
Sb	0.36	0.14	0.43	0.32	0.09	0.08	0.07	0.19	0.14	0.11	0.21	0.10	2.25	0.19
Ta	0.15	0.19	0.46	0.23	0.06	0.23	0.07	0.03	0.06	0.04	0.05	0.05	1.61	0.13
W	0.48	0.30	0.67	0.31	0.43	1.05	0.13	0.11	0.19	0.47	0.70	0.90	5.73	0.48
Tl	0.03	0.03	0.02	0.01	-0.00	-0.00	0.00	0.00	-	0.00	0.01	0.00	0.10	0.01
AS	5.14	0.94	3.20	1.84	0.14	0.15	0.50	0.62	0.42	1.60	1.07	0.55	16.16	1.35
Ga	3.23	5.26	5.92	3.26	0.85	0.65	2.60	0.82	1.52	1.12	3.00	1.55	29.78	2.48
Ti	944.3	127.34	436.14	1427	849.02	373.40	777.41	495.30	697.04	448.06	457.89	476.25	11307	1027
P/Ti	0.58	0.43	0.013	0.39	0.66	1.49	0.715	1.12	0.8	0.66	2.14	1.39	10.39	0.87
U/Th	0.66	0.61	0.22	0.24	0.61	0.81	1.85	1.29	0.53	0.49	0.62	0.51	8.44	0.70
V/Cr	0.65	0.67	1.822	2.31	0.35	0.39	0.73	0.51	0.27	0.48	0.69	0.37	9.24	0.77
Ni/co	2.51	3.31	2.04	2.23	6.66	5.87	2.81	4.41	4.56	5.25	3.27	3.47	46.39	3.87
Sr/Ba	5.69	13.95	5.79	3.41	24.24	49.59	44.74	46.85	37.34	34.79	41.69	64.73	372.81	31.07
Cu/Zn	0.09	0.13	0.02	0.07	0.14	0.08	0.07	0.20	0.12	0.17	0.08	0.24	1.41	0.12
Zr/Rb	5.23	0.21	68.08	23.81	7.33	7.43	2.44	2.64	3.07	2.77	2.39	2.70	128.10	10.68
Th/Cr	0.07	0.06	0.08	0.07	0.04	0.03	0.06	0.05	0.03	0.04	0.05	0.03	0.61	0.05
Cr/Th	14.29	16.67	12.50	14.29	25.00	33.30	16.67	20.00	33.30	25.00	20.00	33.30	264.32	22.03
Th/Sr	0.56	0.33	0.96	0.66	0.78	0.61	0.46	0.75	0.97	0.76	0.73	0.68	8.25	0.69
Th/Co	0.33	0.53	1.17	0.71	0.89	1.10	0.55	0.49	0.98	0.92	0.62	0.66	8.95	0.75
V/(V/Ni)	0.56	0.64	0.93	0.91	0.68	0.70	0.78	0.55	0.68	0.70	0.73	0.70	8.56	0.71
Sr/Cu	34.37	62.90	38.59	30.15	55.78	66.29	171.34	90.98	97.85	73.61	106.41	88.17	916.44	76.37
Th/Sc	0.56	0.33	0.96	0.66	0.78	0.61	0.46	0.75	0.97	0.76	0.74	0.68	8.22	0.69
Th/U	1.51	1.64	4.60	4.26	1.64	1.23	0.54	0.78	1.88	2.03	1.60	1.96	23.67	1.97
Rb/Sr	0.04	0.03	0.03	0.03	0.009	0.005	0.08	0.06	0.01	0.007	0.007	0.004	0.31	0.03
Zr/Rb	5.23	2.13	68.30	23.82	7.34	6.9	2.44	2.64	2.82	2.77	2.39	2.70	129.48	10.79

Results and Discussion

Table 5: Distribution of rare element concentration (ppm) for the study well

Ppm	IT2	IT5	IT13	IT14	IT16	IT17C	IT19	IT22	IT26	IT28	IT30	IT32	∑REE	AVG
	Sandstones		Limestone											
La	10.325	15.26	19.52	12.604	4.06	3.107	10.472	4.303	6.837	5.807	18.162	8.029	118.486	9.87
Ce	20.093	27.198	48.302	31.116	6.351	4.829	21.936	6.591	11.188	8.289	28.409	12.54	226.839	8.90
Pr	2.218	2.95	4.979	3.242	0.88	0.695	2.486	0.948	1.625	1.34	3.984	1.827	27.174	2.26
Nd	8.812	11.182	20	13.013	3.67	2.856	10.397	3.976	6.808	5.603	16.264	7.669	110.25	9.19
Sm	1.669	1.891	4.344	2.57	0.715	0.595	1.915	0.807	1.285	1.095	3.087	1.497	21.47	1.79
Eu	0.378	0.42	1.053	0.619	0.171	0.143	0.445	0.192	0.297	0.256	0.704	0.342	5.02	0.42
Gd	1.522	1.575	4.116	2.315	0.694	0.596	1.726	0.779	1.163	1.028	2.727	1.37	19.611	1.63
Tb	0.205	0.207	0.629	0.326	0.098	0.083	0.224	0.109	0.153	0.141	0.375	0.185	2.735	0.23
Dy	1.168	1.19	3.783	1.903	0.577	0.505	1.25	0.639	0.875	0.825	2.143	1.053	15.911	1.33
Y	6.151	6.939	20.267	9.11	3.58	3.486	7.985	4.436	5.55	5.802	13.751	7.708	94.765	7.90
Ho	0.224	0.228	0.747	0.36	0.115	0.099	0.228	0.127	0.169	0.16	0.403	0.212	3.072	0.26
Er	0.615	0.615	2.154	0.977	0.312	0.268	0.586	0.341	0.446	0.427	1.058	0.547	8.346	0.70
Tm	0.089	0.088	0.342	0.149	0.045	0.038	0.078	0.047	0.059	0.059	0.145	0.075	1.214	0.10
Yb	0.57	0.566	2.373	0.96	0.281	0.232	0.49	0.281	0.366	0.344	0.86	0.454	7.777	0.65
Lu	0.086	0.087	0.377	0.145	0.043	0.035	0.074	0.043	0.055	0.052	0.131	0.071	1.199	0.10

Results and Discussion

PAAS-normalized trace and rare earth elements distribution of itori limestone samples

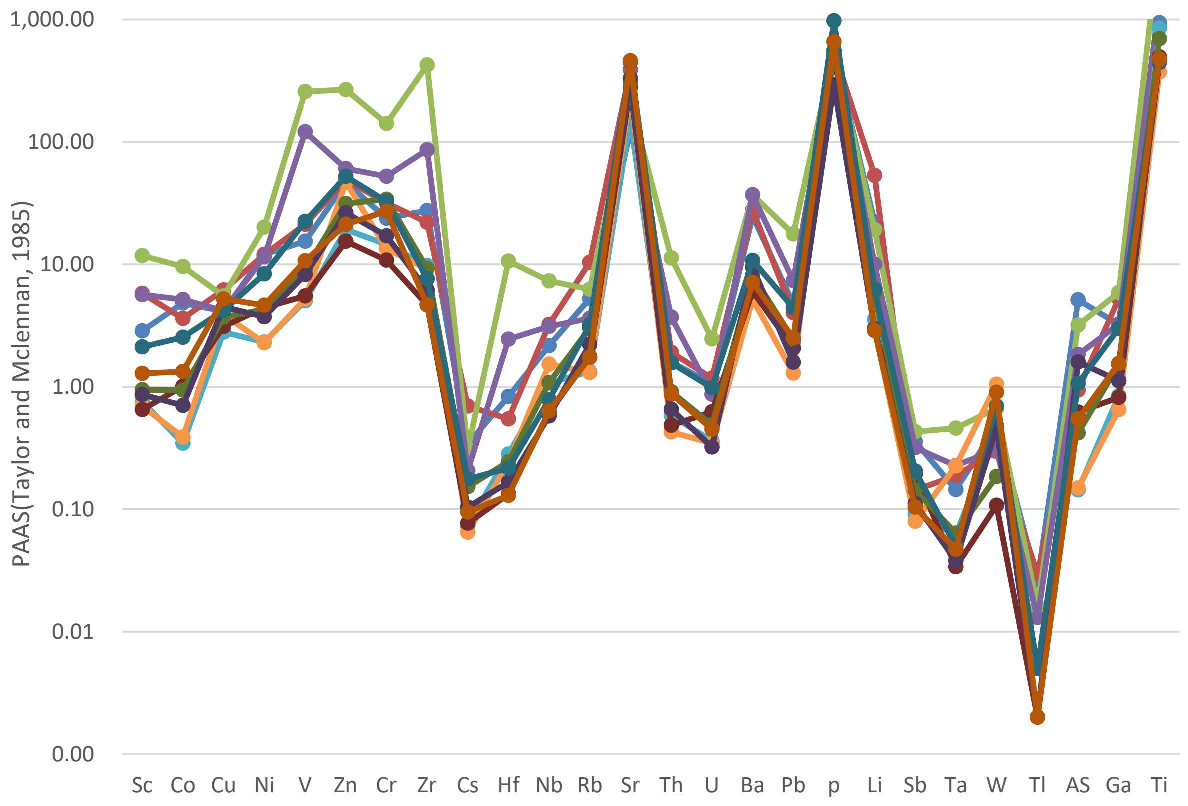

Fig 6 : PASS- normalized trace element distribution of Itori well.

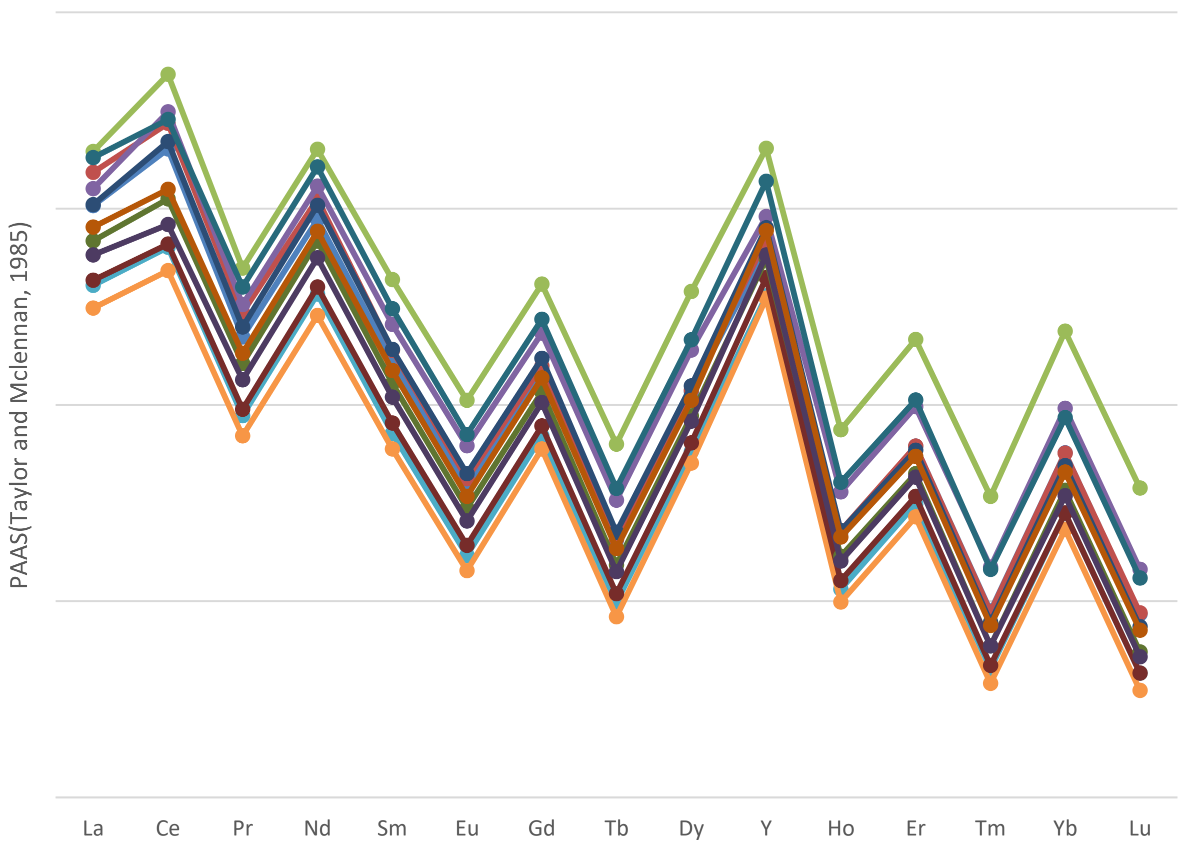

Fig 7: PASS- normalized rare element distribution of Itori well.

Results and Discussion

Provenance

The Th/Sc, Th/Co and Th/Cr, Cr/Th ratios of the Itori well sediments, compared with those of sediments derived from felsic and mafic rocks as well as to average values of upper continental crust (UCC) and Post Archean Australian Shale (PAAS) values suggest intermediate to felsic provenance for the sediments as shown in Table 6.

Modal sandstone composition consist of sub rounded grain, monocrystalline and polycrystalline quartz grains, rock fragment, rutile, garnet and tourmaline, suggest a mixed provenance of metamorphic, plutonic and recycled sedimentary sources.

Table 6: Range of elemental ratios in this study compared to the ratios in sediments derived from felsic rocks, mafic rocks, Upper Continental Crust (UCC) and Post-Archean Australian shale (PAAS).

Elemental ratio	Range for present study[1]		Range of sediment[2]		UCC[3]	PAAS[3]	Remark on provenance
	Min	Max	Felsic	Mafic rock			
Th/Sc	0.3	0.97	04.0-0.94	0.71-0.95	0.63	0.66	Intermediate-felsic rock
Th/Co	0.33	0.89	0.67-19.40	0.04-1.40	0.63	0.63	Intermediate-felsic rock
Th/Cr	0.03	0.08	0.13-2.70	0.02-0.05	0.13	0.13	Intermediate-felsic rock
Cr/Th	12.50	33.30	4.00-15.00	25-500	7.76	7.53	Intermediate-felsic rock

Results and Discussion

Tectonic Setting

Cross plot of K_2O/Na_2O vs SiO_2, (Roser and Korsch,1986) (fig 8) , established that the sediments plotted dominantly in the Active Continental Margin and Passive Continental Margin , Suggesting a syn-rift faulting setting of a transform margin; it also suggests that the sediments deposition in this basin must have come from multiple sources, of igneous and gneissic origin plus reworked older clastic sediments (fig 10a and b)(Madukwe et al., 2015) .

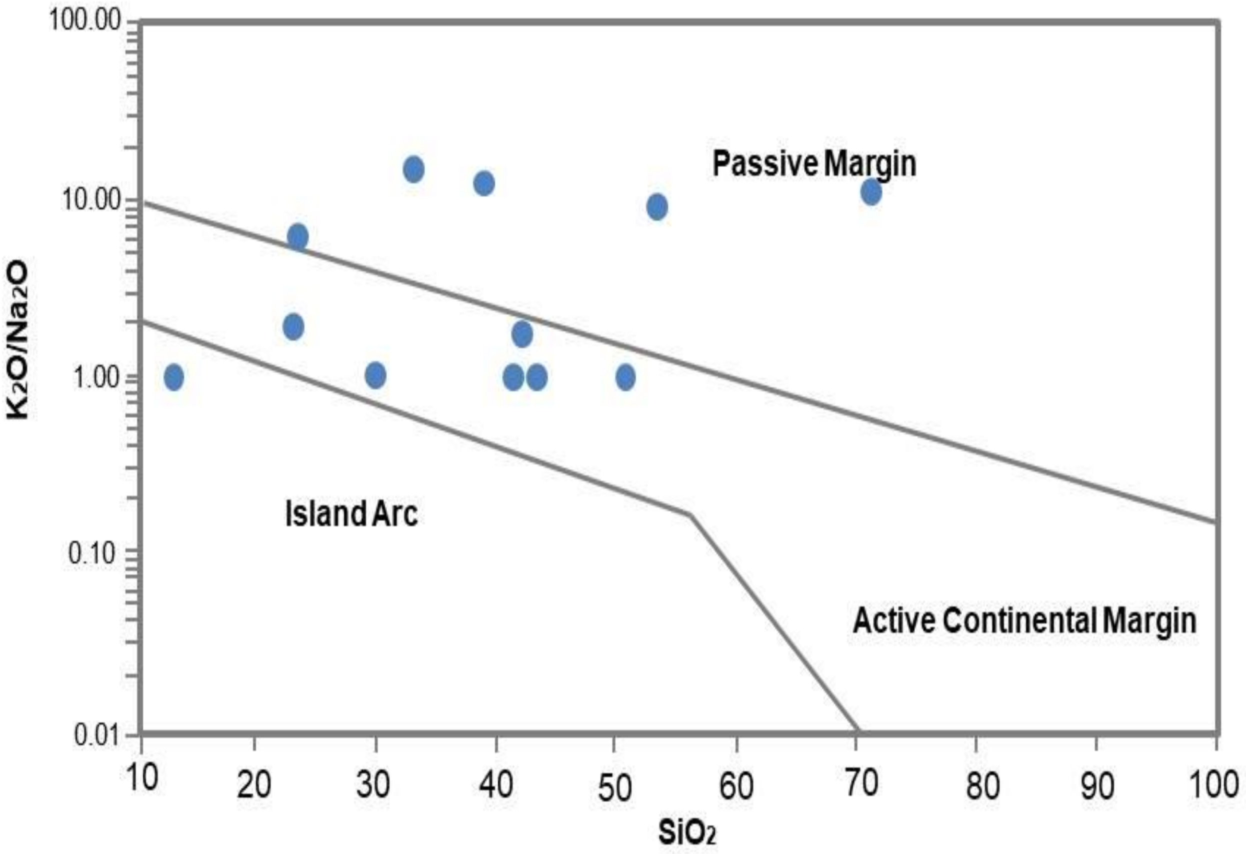

Fig 8: Provenance discrimination diagram of Roster and Korsch (1986) for Itori well sandstone

Results and Discussion

Tectonic Setting continuation

Also, Cross plot of SiO_2 against total Al_2O_3 + K_2O+ Na_2O (fig 9), also shows a semi humid climatic condition with increase chemical maturity.

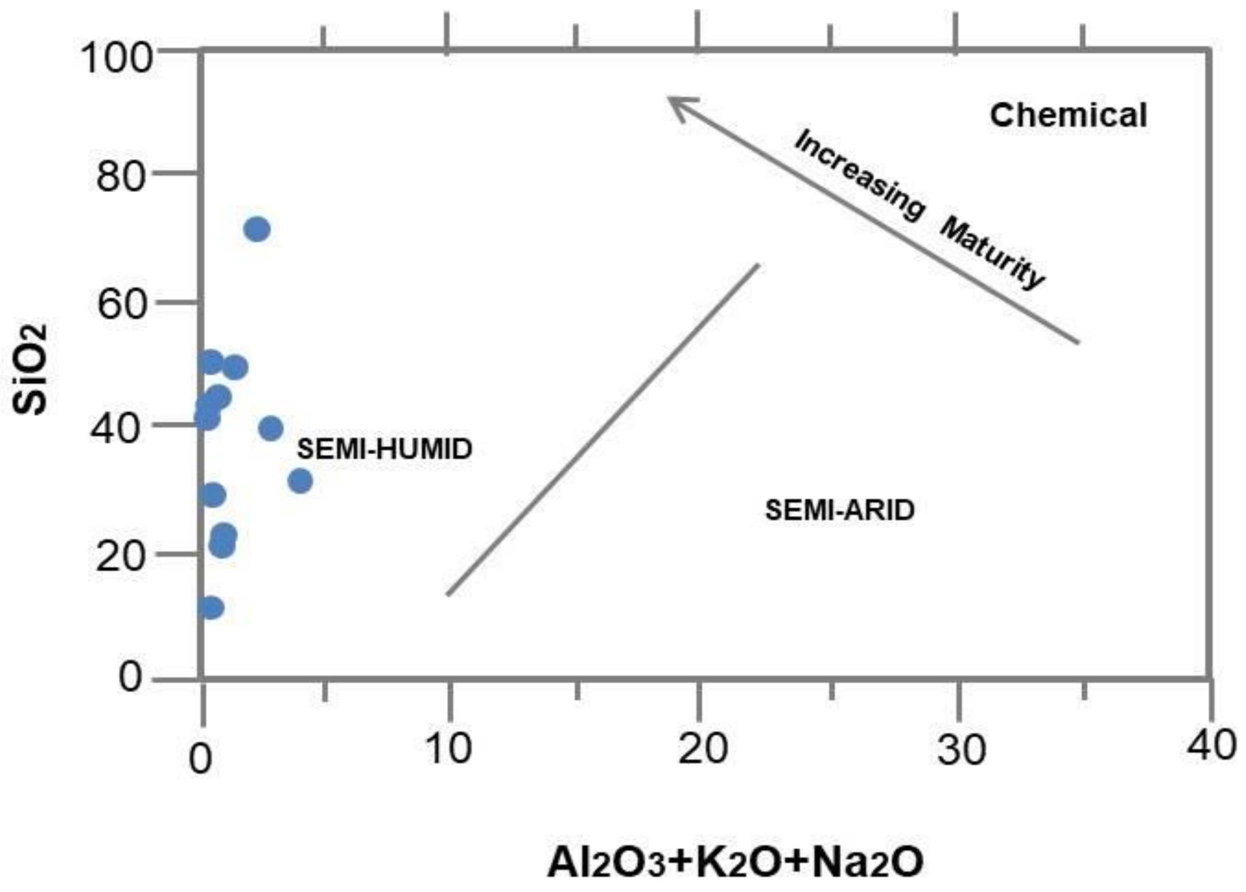

Fig 9: SiO_2 against total (Al_2O_3 + K_2 + Na_2O) showing trend of maturity and paleoclimatic conditions (After: Suttner and Dutta, 1986).

Results and Discussion

Tectonic Setting continuation

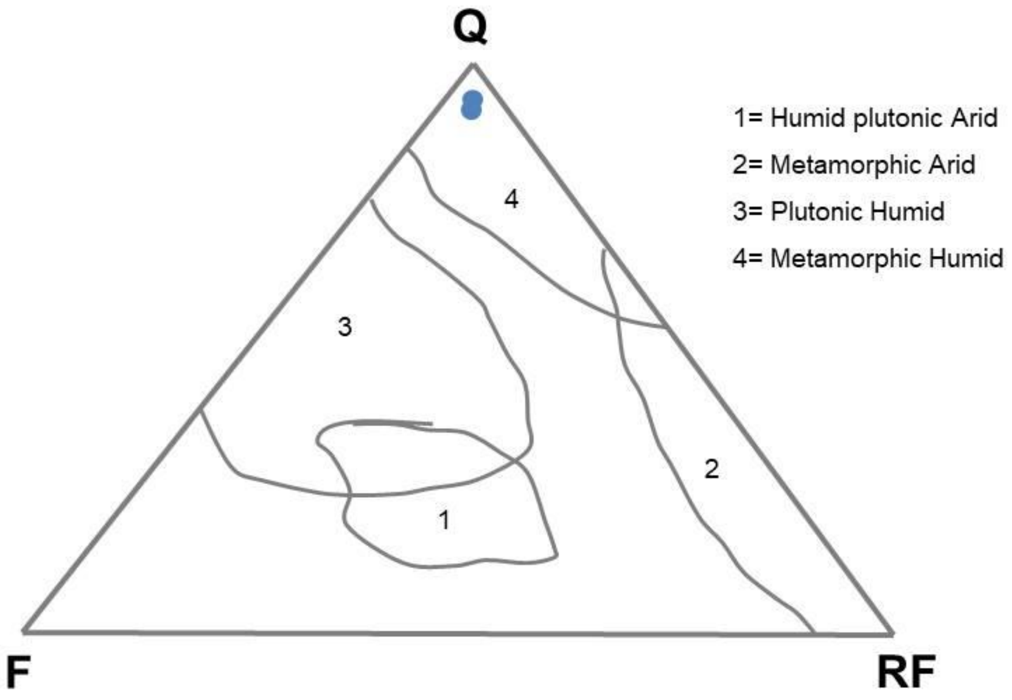

Fig 10 a. Ternary plot of QFR showing the paleoclimatic setting of Itori well sandstone samples (After: Suttner et al 1981)

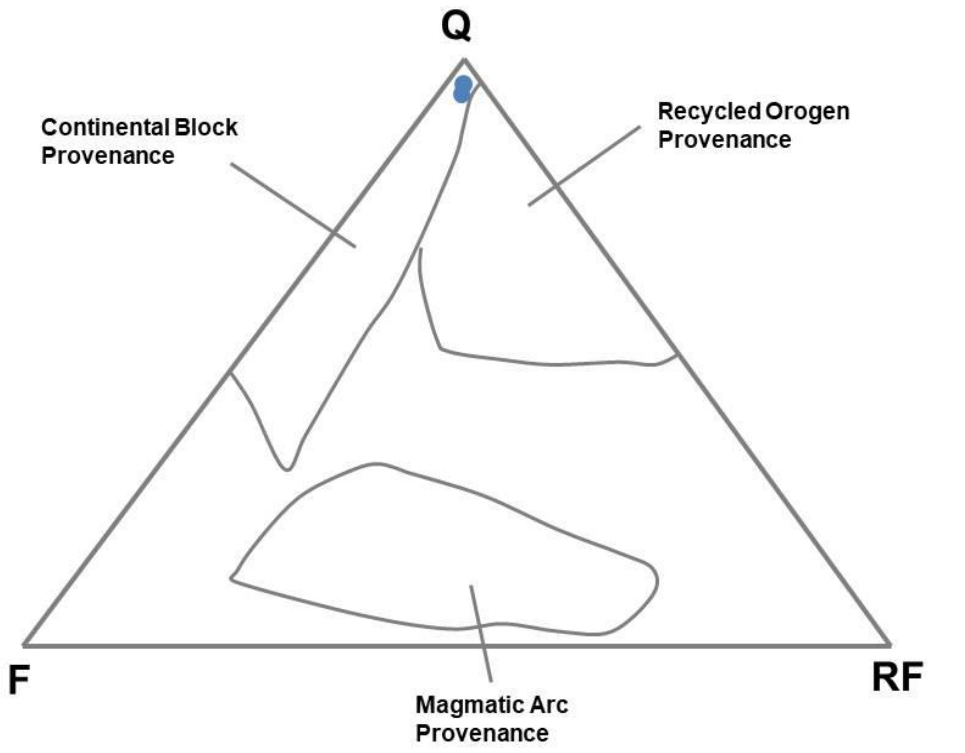

Fig 10: b Ternary plot of QFR showing paleo- tectonic settings of Itori well sandstone samples (After: Dickinson and Suczek, 1979).

Results and Discussion

Paleo-Redox Conditions.

The values of Ni/Co range from 2.04-5.87ppm (av. 3.87) also suggesting an oxic condition. U/Th value ranges from 0.22 -0.62ppm (avg 0.77pm) indicating deposition of sediment in dysoxic condition. In addition, V/(V + Ni) ratio ranges 0.55- 0.93ppm (av. 0.71ppm) Table 4, indicating deposition in an anoxic.

Paleo-Productivity

Lower productivity is indicated by a P/Ti value of less than 0.34, intermediate productivity is characterized by a P/Ti value of 0.34–0.79, and a P/Ti value of more than 0.79 indicates high productivity (Li *et al*., 2020). In this study, the P/Ti ratio ranges from 0.013-2.14ppm (average 0.87ppm) Table 4, indicating high productivity.

Paleo-Hydrodynamic conditions

A higher Zr/Rb ratio indicates shallow water circulation and stronger hydrodynamic pressure. The Zr/Rb ratio <0.92 shows a weak paleo-hydrodynamic regime, 1.25– 4.76 means intermediate to strong hydro dynamic pressure and 4.76 indicates a strong paleo-hydrodynamic regime(Teng, 2004; Pehlivanli, 2019). In this study, the Zr/Rb ratio ranged from 0.21 - 68.08 (av., 10.68ppm) Table 4, indicating deposition of sediments under a strong paleo-hydrodynamic condition.

Summary and conclusion

- The sandstone samples classified as Quartz Arenite.
- The limestone on the other hand revealed two microfacies namely; Sandy Bioclast packstone bioclastic – wackstone-packstone.
- The Th/Sc, Th/Co and Th/Cr, Cr/Th ratios of the sediments suggest intermediate to felsic provenance for the sediments.
- Ternary plot of the sandstone revealed metamorphic humid climate setting.
- Cross plot of K_2O/Na_2O vs SiO_2, revealed Active Continental Margin and Passive Continental Margin tectonic setting.
- Also, a bivariate plot of SiO_2 against total (Al_2O_3 + K_2 O+ Na_2O) revealed the prevalence of semi-humid conditions for the sediments with increasing chemical maturity.
- The ratio of V/Cr ranged from 0.27-2.31(av. 0.77ppm) indicating deposition under oxic condition V/Cr ranged from 0.27-2.31(av. 0.77ppm) indicating deposition under oxic condition

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Thank you for listening