International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 3 Issue 2 ǁ February. 2015 ǁ PP.01-09

Geochemistry and Tectonic Setting of Cretaceous Sediments from Al Bauga Area, Bayuda Desert, River Nile State, Sudan.

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Abstract: Geochemistry; major and trace elements of Al Bauga sediments have been investigated to understand their provenance and tectonic setting. The tectonic discriminant diagrams placed the majority of Al Bauga sediments within the passive margin setting. These sediments generally, are enrich in SiO_2 and depleted in K_2O and Na_2O. The discriminant function diagram of major elements, the enrichment of Zr, Th, La and lack of V, Co and Ni indicate that the source area of most of Al Bauga sediments are felsic provenance.

Key Words: Geochemistry, major and trace elements, tectonic setting, passive margin, Al Bauga sediments.

I. Introduction

Geochemistry of sediments can lead to understand the relation between geochemical composition, provenance, tectonic setting and source area of ancient sedimentary rock. The usefulness of major (Bhatia, 1983; Roser and Korsch, 1987; McLennan, 1989; Armstrong-Altrin and Verma,, 2005;Al-Juboury,2007; Huntsman-Mapila, et al.,2009;Zaid,2012) and trace (Bhatia and Crook, 1986; Etemad-Saeed, et al., 2011and Elzien & Farah, 2013) elements geochemistry discrimination diagrams to infer the tectonic setting of sedimentary rocks. In this paper we try to construct tectonic setting and provenance of Al Bauga sediments using geochemical approach.

II. General Geology

Al Bauga area is a part of Bayuda Desert (Fig.1), the general geology of Bayuda Desert according to Vail, 1979; Barth & Meinhold, 1979;Almond, et al., 1983; Meinhold, 1983; Hamed, B. O., 2005 and

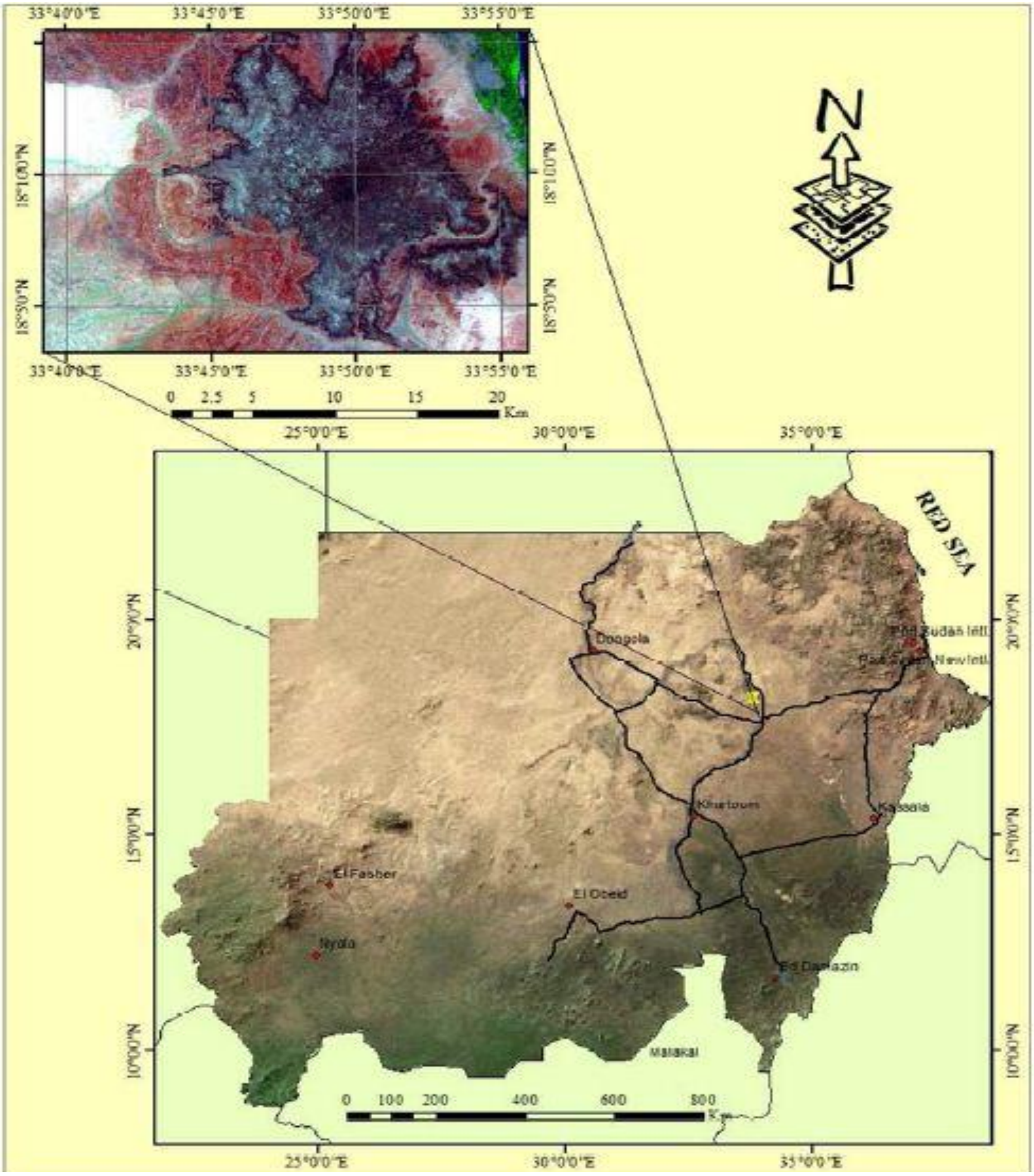

Fig.1: Location Map of Al Bauga area

Elzien, et al., (2013) consist of Precambrian basement complex; Abu Harik Series and Bayuda Formation(Kurmut Series, Rahaba Series and Absol Series), Paleozoic sedimentary formation; Amaki Series, Paleozoic igneous ring complex, Mesozoic sedimentary formation, Cenozoic Basaltic Shield volcanoes and Pleistocene to recent deposits (Fig.2).

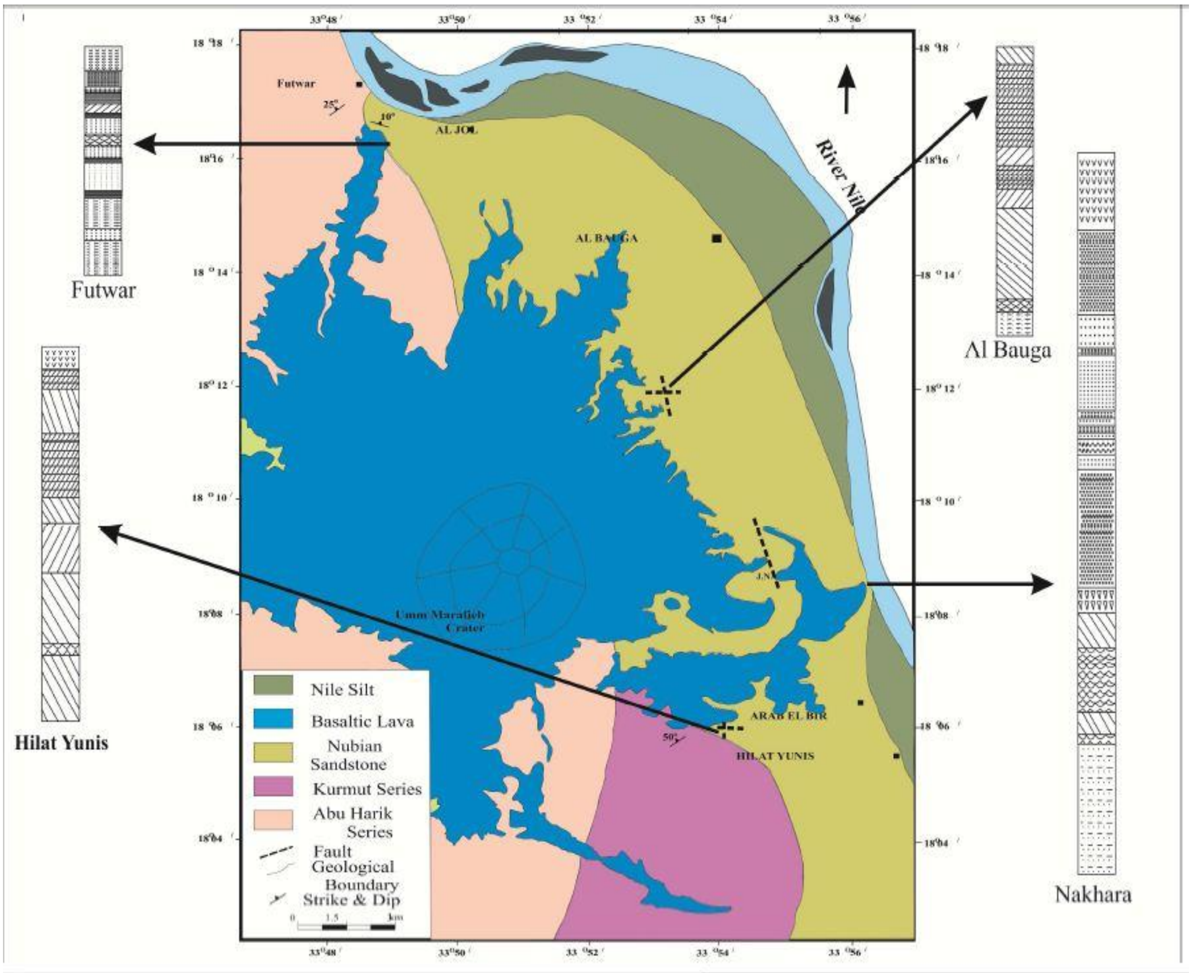

Fig.2: Geological Map of Al Bauga area

III. Material and Methodology

Samples were collected from four outcrops; Hilat Yunis, Nakhara, Al Bauga and Futwar profiles .Chemical analysis for samples were performed by X-ray fluorescence, Spectrophotometer and Atomic Absorption Spectroscopy at the Central Petroleum Laboratories (CPL) in Khartoum.

IV. Results

The major and trace elements of Al Bauga sediments; Hilat Yunis, Nakhara, Al Bauga and Futwar profiles are listed in Tables(1-8), respectively.

Major elements

The major elements of Al Bauga area show wide variation in their concentration; Hilat Yunis silica contents varies in the range of (79.71- 95.80)%, Al_2O_3 (3.14- 12.69)%, Fe_2O_3 (0.33-14.42)% and Nakhara SiO_2 (65.63- 93.52)%, Al_2O_3 (0.77 -15.74)%, Fe_2O_3(2.91-15.16)%,Al Bauga SiO_2(75.18-99.01)%, Al_2O_3 (0-11.97)%, Fe_2O_3 (0.43-9.72)% and Futwar SiO_2(84.16-97.83)%, Al_2O_3(0.84-11.35)%, Fe_2O_3 (0.01-4.53)%.

Trace elements

The trace elements of Hilat Yunis profile shows various concentration with high in Ba (223.2ppm), Cr (293ppm), Co(338.1ppm), S (9100ppm), the Nakhara profile is high in Ba (2200ppm), Cr (439ppm), Sr (466.1ppm), Zr (3000ppm), S (7400ppm), Al Bauga Ba (854.6ppm), Cr (172.7ppm),Co (129.9ppm),V (269.8ppm), Zr (1686.5ppm), S (39700ppm) and Futwar Ba (953.4pmm), Cr (264.3ppm),Z r (1641.1ppm) and S (2700ppm).

Table1: Major elements (%) composition of Hilat Yunis Profile.

Oxide	Y.2	Y.4	Y.5	Y.7	Y.8	Y.11	Y.13	Y.14	Y.16	Y.17	Y.18	Y.19	Y.20	Y.22	Y.24	Y.25
SiO2	92.37	95.8	94.23	94.17	94.93	90.63	84.85	86.78	83.99	85.87	87.69	84.68	91.37	88.14	80.85	79.71
Al2O3	5.02	3.14	4.26	4.44	3.28	8.34	12.84	8.46	12.69	6.69	10.677	11.04	4.89	3.82	3.29	6.89
TiO2	0.8	30	0.48	0.58	0.74	0.48	0.37	0.94	1.03	1.47	0.25	1.27	0.41	0.2	0.19	0.37
FeO	0.006	0.005	0.007	0.008	0.012	0.013	0.012	0.08	0.01	0.014	0.014	0.01	0.01	0.01	0.02	0.025
Fe2O3	0.91	0.33	0.56	0.5	0.37	0.39	1.26	2.8	1.01	5.13	0.63	1.49	2.4	1.48	14.42	1.55
MnO	0.01	0.006	0.01	0.009	0.008	0.008	0.02	0.03	0.02	0.07	0.014	0.03	0.04	0.02	0.07	0.04
MgO	0.001	0.001	0.001	0.0005	0.001	0.001	0.001	0.001	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001
CaO	0.72	0.29	0.34	0.24	0.61	0.32	0.5	0.81	1.12	0.48	0.46	1.31	0.7	2.99	0.68	6.01
Na2O	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
K2O	0.15	0.06	0.09	0.05	0.04	0.08	0.14	0.11	0.13	0.09	0	0.162	0.1	0.09	0.185	0.142
P2O5	0	0.074	0	0	0	0	0	0	0	0.183	0.26	0	0.06	3.23	0.28	5.39

Table2: Major elements (%) composition of Nakhara Profile.

Oxide	N.1	N.4	N.5	N.6	N.8	N.9	N.11	N.12	N.16	N.18
SiO2	73.1	65.63	75.09	63.67	73.84	86.97	83.02	80.49	93.52	75.62
Al2O3	14.27	15.69	15.68	15.74	15.44	5.03	7.58	7.41	0.77	2.81
TiO2	3.32	3.63	3.36	2.1	2.53	1.73	3.29	2.39	0.57	1.15
FeO	0.013	0.021	0.01	0.021	0.01	0.01	0.01	0.01	0.01	0.01
Fe2O3	7.2	13.66	3.44	15.16	4.97	3.87	3.76	7.45	2.91	14.14
MnO	0.02	0.03	0.03	0.38	0.04	0.09	0.04	0.41	0.04	0.27
MgO	0.004	0.003	0.002	0.003	0.004	0.001	0.002	0.002	0.001	0
CaO	1.36	0.76	0.88	1.69	2.31	0.65	1.34	0.92	1.05	4.44
Na2O	0.004	0.002	0.002	0.003	0.002	0.001	0.002	0.001	0.001	0.11
K2O	1.71	0.998	1.5	1.13	0.85	1.61	0.95	0.79	0.87	1.73
P2O5	0	0	0	0.09	0	0.06	0	0.13	0.24	0

Table3: Major elements (%) composition of Al Bauga Profile.

Oxide	FBOO	FB1	B.1	B.2	B.4	B.8	B.10	B.14	B.17	B.18	B.21	B.22	B.23	B.25
SiO2	75.18	81.15	93.39	97.5	90.36	97.65	99.01	97.44	91.04	89.78	81.36	92.46	93.14	95.57
Al2O3	5.9	11.35	2.95	0	6.22	0	0	0	3.48	6.82	11.97	5.23	2.69	1.31
TiO2	2.7	2.1	0.56	0.63	0.85	0.61	0.18	0.73	1.37	0.68	2.41	0.69	1.55	0.54
FeO	0.015	0.007	0.006	0.006	0.009	0.008	0.006	0.008	0.007	0.007	0.008	0.009	0.006	0.007
Fe2O3	9.72	4.43	1.81	1.06	1.42	1.03	0.43	1.26	2.01	1.33	2.92	1.06	1.65	1.074
MnO	0.07	0.053	0.029	0.014	0.016	0.008	0.009	0.012	0.019	0.01	0.019	0.009	0.021	0.021
MgO	0	0.001	0.001	0.0002	0.0006	0.0004	0.0004	0.0003	0.0005	0.0004	0.0003	0.0005	0.0004	0.0007
CaO	5.93	0.13	0.5	1.29	0.82	0.35	0.18	0.21	1.84	1.2	1.13	0.46	0.7	0.62
Na2O	0.002	0.001	0.001	0.001	0.0005	0.0005	0.0004	0.0004	0.001	0.0007	0.001	0.0005	0.0007	0.0007
K2O	0.52	0.78	0.24	0.094	0.134	0.11	0.101	0.13	0.23	0.16	0.19	0.17	0.14	0.072
P2O5	0	0	0.52	1.4	0.176	0.13	0.081	0.21	0	0	0	0	0.104	0.12

Table4: Major elements (%) composition of Futwar Profile.

Oxide	F.0	F.3	F.4	F.7	F.8	F.9	F.10	F.11	F.12	F.14	F.15	F.16	F.17
SiO2	85.51	91.04	90.62	84.16	84.53	86.97	87.1	97.83	90	90.88	93.6	95.55	94.53
Al2O3	11.35	4.79	4.71	8	6.65	6.93	7.23	0.84	6.44	6.28	3.77	4.5	2.73
TiO2	1.65	1.18	1.19	2.44	3.15	1.16	3.38	0.25	0.68	1.73	0.45	1.77	0.53
FeO	0.008	0.008	0.011	0.01	0.013	0.0089	0.011	0.009	0.008	0.007	0.008	0.014	0.014
Fe2O3	0.95	1.92	2.54	3.67	4.53	3.38	1.36	0.57	1.99	0.5	1.51	0.52	1.64
MnO	0.012	0.143	0.143	0.093	0.24	0.056	0.089	0.012	0.019	0.015	0.02	0.021	0.019
MgO	0.0003	0.001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0001	0.0001	0.0001	0.0009	0.005	0.0008
CaO	0.19	0.75	0.53	1.043	0.7	1.024	0.71	0.42	0.57	0.48	0.38	0.48	0.32
Na2O	0.001	0.001	0.0008	0.0007	0.0008	0.0008	0.0007	0.0008	0.0008	0.0008	0.0009	0.0008	0.0009
K2O	0.16	0.17	0.23	0.58	0.18	0.46	0.113	0.095	0.28	0.11	0.17	0.104	0.089
P2O5	0.155	0	0.031	0	0	0	0	0.007	0	0	0.09	0.04	0.13

Table5: Trace elements (ppm) composition of Hilat Yunis Profile.

SN	Rb	Sr	Y	Zr	Nb	Cs	Ba	Hf	Ta	Pb	Th	U	Sc	V	Cr	Co	Ni	La	Ce	Pr	Nd
Y.2	3.9	36.5	32.6	201.1	11.7	0	223.3	121.5	0	11.8	0	3.7	0	0	293	43.4	52.5	0	82.1	0	0
Y.4	2.3	7.3	7.9	95.5	0.5	11.1	55.9	0	65.2	2.9	0	2.5	3.3	0	92	0	0.6	26.8	9.5	0	0
Y.5	0	12.4	14.2	124.9	5.1	0	99.7	54.3	0	9	0	5	0	0	91	67.8	18.4	15.5	14.2	35.4	0
Y.7	2.6	9.3	15.1	115.8	5.2	0	61.7	16	22.9	2.3	6.1	3.8	0	0	56.8	18.9	19.4	17.6	27.9	7.5	0
Y.8	2.3	8	13.7	253.6	6.9	7.2	61.4	0	54.6	15.1	0	9.6	0	0	73.4	24.9	10.2	0	8.4	0	0
Y.11	4	8.2	11.8	93.1	11.4	2.7	66.1	0	0	8.1	7.4	0	0	0	51.7	20.1	0	10.1	56.5	40.1	34.5
Y.13	1.8	14.8	35	352	10.3	0	100.5	23.7	0	27.3	4.8	5.4	5.6	0	93	9.2	6.6	22.9	83.2	0	16.8
Y.14	0.5	12	36	262.4	11.2	0	92.1	45.9	31.6	10.8	6.6	0	18.4	52.3	100	38.6	10.7	12.3	38.1	0	64.8
Y.16	5	18.6	34.6	289.5	15.5	2.7	114.3	59.5	0	20.4	0	5	0	0	55.1	27.3	10.7	19.1	38.5	23.3	0
Y.17	7.6	28.9	114	706.2	21.8	3.4	287.1	77.6	112.3	25.4	24.4	0	0	70.5	148	155.6	0	30.1	105.8	47.9	0
Y.18	0	28.4	34.1	280.8	6.7	7.7	168.1	68.2	0	0	26.5	0	0	0	75	31.6	12.5	2.3	87.6	0	0
Y.19	11	33.3	48.1	485.1	12.9	0	173.3	47.3	67.9	9.5	25.3	10.4	3.7	0	133	86.2	18.9	39.3	93.6	38.4	0
Y.20	4.9	29.4	47.4	126.7	6.6	3.7	145.6	19.5	129.7	25.1	0	0	42.4	0	1166	126.1	53.1	48.8	96.7	0	117
Y.22	0.7	17.3	46	66.9	3.1	19.1	103.5	58.3	33.3	0	0	5.3	81.3	6.3	60.4	35	0	54.6	105.4	0	33.9
Y.24	2.5	24.6	43.2	46.3	2.5	0	193.2	220.3	0	0	0	0	57.1	9.4	166	338.1	0	10.2	39.6	0	0
Y.25	3	28.2	28.1	69.7	1.4	0	153.3	0	78.1	0	29.3	2.3	80.4	4.9	73.3	36.1	0	6.9	19.3	8.3	0

Table6: Trace elements (ppm) composition of Nakhara Profile.

SN	Rb	Sr	Y	Zr	Nb	Cs	Ba	Hf	Ta	Pb	Th	U	Sc	V	Cr	Co	Ni	La	Ce	Pr	Nd
N.1	55.3	187.7	61.6	588.7	96.1	0	858.7	151.2	0	9.2	0	21	0	72.3	0	142.9	3.8	34.8	152	41.6	7.2
N.4	49.3	141.7	91.8	3000	66.8	0	858.9	335	111	26.4	42.7	12	0	0	301.2	316.9	1.7	129.4	238	22.8	0
N.5	30.1	106.2	40.1	1459	53.1	0	916.1	156.8	0	1.5	7.3	0	0	0	137.4	76.3	0	20.5	168	20.5	0
N.6	33.6	277	92.3	1154.5	52.6	37	1497.7	240.2	0	35.2	0	0	331.8	0	235.5	439.6	0	97.2	247	0.2	75.4
N.8	31.2	466.1	55.2	735.1	46.5	0.9	734.6	126	0	31.6	16.9	0	94.7	0	394.3	183.6	83.7	96.9	163	4.8	0
N.9	32.6	93.2	18.4	479.2	0	49	48.5	270	0	0	0	0	0	16.2	30.2	35.3	0	0	142	0	0
N.11	20.3	136.3	63.2	1390.5	69.8	9.8	7070.2	0	15.8	1.1	5.3	5.3	146.6	0	11	33.9	0	131.1	130	0	104.1
N.12	19.6	238.4	110	876.9	44.3	0	2200	215.1	79.5	21.1	0	14	33.2	170.6	0	190	0	92.1	930	89.4	202
N.16	14.8	48.2	16.4	182.4	32	0	425.3	0	6.5	32.8	0	8.7	112.6	31.2	23.4	0	0	17.8	118	101	0

Table7: Trace elements (ppm) composition of Al Bauga Profile.

SN	Rb	Sr	Y	Zr	Nb	Cs	Ba	Hf	Ta	Pb	Th	U	Sc	V	Cr	Co	Ni	La	Ce	Pr	Nd
FBI	7.8	134	47.8	785.3	34.1	27.8	418.4	211.5	72	50.1	34.9	0	0	78.2	61	85.5	110	91.9	340	217	153
FBOC	41	578	81.4	1686.5	95.9	36.6	584.6	19.3	99.6	167	56.9	2.7	0	270	0	130	0	128	489	75.7	0
B.1	9.3	29.2	31.3	143.4	40.2	21.7	257.6	96.2	0	5.9	17.7	0.7	0	71.9	17.6	45.8	0	50.7	47.1	0	0
B.2	3.9	20.5	18.8	241.3	0	0	68.6	214.4	0	0	0	0	0	76.4	70.6	0	0	68.3	125	0	0
B.4	0	33.7	13.1	269	4.4	4.9	207.7	0	0	0	2.5	0	44.7	72.6	32.6	0	0	52.9	33.8	37.3	0
B.8	2	18	8.8	244.1	48.2	0	101.9	0	261	7.8	36.8	9.9	0	54.2	111.3	18.1	0	7.8	45.1	0	0
B.10	3.7	21.1	19.9	110.9	11.5	0	63	37.3	159	15.7	62.2	0.6	0	0	91.8	32.9	45.2	0	46.1	0	0
B.14	2.8	13	6	272.4	4.5	48.5	65.2	0	0	0	37	0	0	64.4	90.9	0	0	62.5	0	88.9	0
B.17	3.2	36.8	27.2	580.9	35.7	0	185.6	236	101	94.7	6.9	26.8	0	0	54	0	45.6	0	22.3	4.1	0
B.18	0	34.5	25.3	156.3	13.8	2.4	170	24.6	20	0	4.8	0	0	0	133	0	9.8	19.7	14.9	48	0
B.21	14	54.1	40.1	1429.5	11.9	14.9	285.2	128.5	0	0	0	6.2	48.9	38.3	46.9	118	0	64.3	129	91.1	0
B.22	0	22.5	8.6	174.7	0	7.2	105.5	94	0	38.3	0	0	0	21.1	59.5	77.7	0	0	94.5	18.6	0
B.23	5.8	20.4	19.5	320.7	23.5	0	118.3	0	26.3	42	50.7	0	4.5	0	25.4	47	7.3	0	106	0	0
B.25	0	24.8	10	155.1	0	19.2	98.4	18.6	0	33.2	22.4	15.6	0	0	172.7	79.9	24.8	70.1	0	60.7	53.8

Table8: Trace elements (ppm) composition of Futwar Profile

SN	Rb	Sr	Y	Zr	Nb	Cs	Ba	Hf	Ta	Pb	Th	U	Sc	V	Cr	Co	Ni	La	Ce	Pr	Nd
F.0	11.4	22	31.7	708	20.1	0	129	0	59.2	20.8	19.1	10.2	14	0	127	41.9	0	48.2	59.2	37.6	0
F.3	1.5	39.5	15.6	373	28.6	0	449	110	0	15.2	18.9	5.6	72.2	0	118	53.9	1.2	45.3	228	83.6	0
F.4	6	43	17.4	343	19.9	0	314	0	0	5.5	0	0.2	9.5	0	98.7	127.8	0	62.2	94.7	8.6	42
F.7	12.3	51.9	24.4	399	30.1	77.7	330	244	129	32.4	20.6	0	0	0	220	145	8.2	47.8	165	15.5	0
F.8	3.5	47.9	33.5	1229	36.1	0	953	0	0	42.9	41.7	9.5	95.8	0	264.3	161.9	0	57.7	136	0	0
F.9	17.9	48.7	23.2	272	26.4	0	188	267	176	15.6	0	0	81.3	0	206	27.5	26	70.9	85	0	0
F.10	1.6	58.8	27.6	1641	38	0	497	115	0	8.7	0	24.5	25.7	0	164	0	6	58.2	107	80.3	0
F.11	0	23.8	11.5	87.6	5.5	0	107	76	32.1	28.9	50.7	3	0	0	124	53.6	50.7	10.7	87	0	0
F.12	7.2	59.3	25.1	168	6.4	22	365	29	129	2.5	0	0	0	37.8	133	83	20.9	13.6	0.1	0	0
F.14	0	37.9	18.8	414	31.7	0	122	135	0	0	0	0	0	0	99.7	42.2	0	0	73.1	0	29.7
F.15	4.8	25	15.2	112	12.6	12.8	141	58	48.3	35.6	24.1	1.6	35.9	0	85.5	49.9	33.2	0	59.1	84.3	17.1
F.16	0	65.6	17.9	571	25.2	3.7	151	131	0	7.6	0	0	0	0	102	98.3	0	0	0	14.2	0
F.17	0.7	22.1	13	101	16.7	2.8	103	0	26.4	42.6	0	0	1.1	46.7	78.6	0	0	16	7.6	0	0

V. Discussion

Major element geochemistry of Al Bauga sediments show wide variety in concentration even in their profiles values (Table 9), also when comparison with Ed Debba sandstones after Elzien & Abdelateif (2013), and Upper Continental Crust (UCC) after McLennan (2001) (Table10). The SiO_2 concentration range from 91.07% in Al Bauga profile to 77.1% in Nakhara Profile with average 86.71% which is highest related to Ed Debba. Al_2O_3 is the highest in Nakhara profile (10.0%) with average 6.69% as moderate values between Ed Debba and UCC. The Fe_2O_3 range from 1.9 in Futwar to 7.7% in Nakhara with average 3.5% which is very low relate to Ed Debba area21%. Abundant of alkalis are depleted in Al Bauga area; average of K_2O (0.44%) is high than Ed Debba and the Na_2O (0.004%) lower than the later. The relatively high Fe_2O_3 value in Nakhara profile may be due to the volcanic.

Table 9: Major elements (Av. %) composition of Al Bauga area

Oxide	Yunis	Nakhara	Bauga	Futwar
SiO2	88.50375	77.095	91.07357	90.18
Al2O3	6.860438	10.042	4.137143	5.71
TiO2	2.47375	2.407	1.114286	1.50
FeO	0.016	0.0125	0.007786	0.01
Fe2O3	2.201875	7.656	2.228857	1.93
MnO	0.025313	0.135	0.022143	0.07
MgO	0.000906	0.0022	0.000479	0.00
CaO	1.09875	1.54	1.097143	0.58
Na2O	0.001	0.0128	0.000814	0.00
K2O	0.101188	1.2138	0.219357	0.21
P2O5	0.592313	0.052	0.195786	0.03

Table 10: Major elements (Av. %) composition of Al Bauga, Ed Debba and UCC.

Oxide	Al Bauga	Ed Debba	UCC
SiO2	86.71	66.11	66.00
Al2O3	6.69	0.97	15.20
TiO2	1.87	0.14	0.68
Fe2O3	3.50	21.01	5.03
MnO	0.06	3.90	0.08
MgO	0.00	0.11	2.20
CaO	1.08	0.52	4.20
Na2O	0.00	0.03	3.90
K2O	0.44	0.10	3.40
P2O5	0.22	0.26	0.15

Provenance and tectonic setting

Many types of discrimination diagrams of tectonic settings that use major element geochemistry have been proposed for clastic sediments (Bhatia, 1983; Roser and Korsch, 1986). By used, the (SiO_2/20)-(K_2O+Na_2O)-TiO_2+Fe_2O_3+MgO) ternary diagram of Kroonenberg, (1994), the samples plotted in passive margin field (Fig.3) and the K_2O/Na_2O vs. SiO_2 binary tectonic diagram of Roser and Korsch, (1986) discriminates between oceanic island arc (OIA), active continental margin (ACM) and passive margin (PM) tectonic setting, this diagram classified Al Bauga sediments as passive margin (Fig.4)

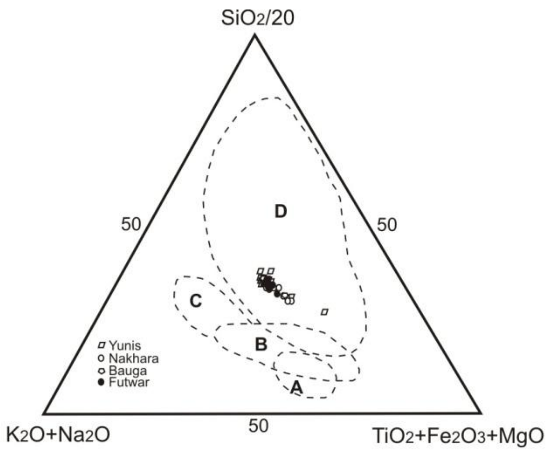

Fig.(3):Tectonic discrimination diagrams for Al Bauga sediments (Kroonenberg,1994).A:Oceanic island Arc, B: Continental island Arc, C: Active continental margin, D: Passive margin.

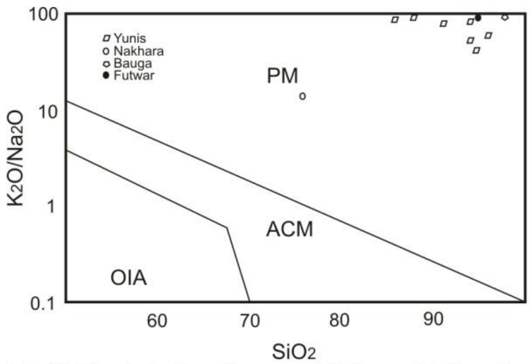

Fig.(4):Discrimination diagram of Al Bauga Sediments K_2O/Na_2O vs SiO_2(after Roser and Korsch,1986). Tectonic fields are oceanic island arc (OIA), active continental margin (ACM)and passive margin (PM).

The sandstone discriminant function diagram of Bhatia (1983) is based on a bivariate plot of first and second discriminant functions for major elements, This plot represents four different tectonic setting (PM,OIA,CIA,ACM). For Al Bauga sediments (Fig. 5) most of the samples plotted in PM Field. Fig.(6) shows the discriminant function diagram for the provenance signatures of Roser and Korsch (1986), all samples of Al Bauga sediments are plotted in felsic igneous provenance except one sample in quartzose sedimentary provenance.

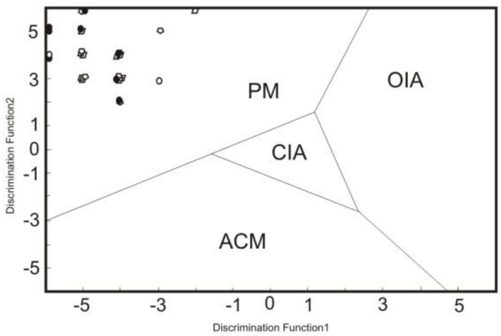

Fig.(5): Tectonic discrimination function diagram of Al Bauga sediments(after Bhatia(1983).

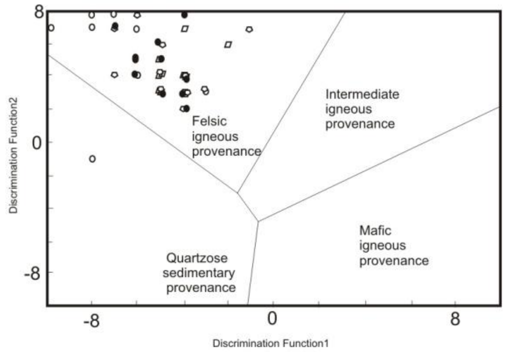

Fig.(6): Provenance discrimination function diagram of Al Bauga sediments(after Roser and Korsch,1988).

Trace element geochemistry

Al Bauga trace element concentrations are varied (Table11). By compared to Ed Debba (Table12) the large ion lithophile element (LILE); Rb, Ba are low, Sr is high and Th, U are similar to Ed Debba, the high field strength element (HFSE);Y is similar and Zr, Nb are high relatively to Ed Debba and the HFSE are enriched in felsic rather than mafic rocks (Etemad-Saeed, et al., 2011), and the transition trace element (TTE) such as V, Co, and Ni are low and Sc high than Ed Debba. The low ferromagnesian trace element concentrations in Al Bauga sediments provide no support for significant amounts of mafic and/or ultramafic rocks in source area.

Table11: Trace elements (average ppm) composition of Al Bauga area.

SN	Rb	Sr	Y	Zr	Nb	Cs	Ba	Hf	Ta	Pb	Th	U	Sc	V	Cr	Co	Ni	La	Ce	Pr	Nd
Yunis	3.3	19.8	35.1	223.1	8.3	3.6	131.2	50.8	37.2	10.5	8.2	3.3	18.3	9.0	170.5	66.2	13.4	19.8	56.7	12.6	16.7
Nakhara	31.9	188.3	61.0	1096.3	51.2	10.7	1623.3	166.0	23.7	17.7	8.0	6.8	79.9	32.3	125.9	157.6	9.9	68.9	254.1	31.1	43.2
Bauga	6.7	74.4	25.6	469.3	23.1	13.1	195.0	77.2	52.8	32.5	23.8	4.5	7.0	53.4	69.1	45.3	17.4	44.0	106.6	45.8	14.8
Futwar	5.1	42.0	21.1	493.7	22.9	9.2	296.1	89.6	46.2	19.9	13.5	4.2	25.8	6.5	140.1	68.1	11.2	33.1	84.8	24.9	6.8

Table12: Trace elements (average ppm) composition of Al Bauga, Ed Debba and UCC.

Name	Rb	Sr	Y	Zr	Nb	Ba	Th	U	Sc	V	Cr	Co	Ni	La
Al Bauga	12	81	36	571	26	561	13	5	33	25	126	84	13	41
Ed Debba	25	52	35	16	6	6706	11	4	4	113	42	707	168	12
UCC	112	350	22	190	12	550	11	3	14	107	83	17	44	30

Provenance and tectonic setting

Due to their relatively immobile nature, the distribution of selected trace elements, such as the Th, Zr, Sc, V, Cr, Co and Ni are particularly useful indicators of Provenance of clastic sedimentary rocks (Varga and Szakmany, 2004). Th, Zr and La are enriched in felsic rocks. Also the trace element very useful to construct palaeotectonic settings, by applying La-Th-Sc and Th-Sc-Zr/10 ternary diagram diagrams (Bhatia and Crook, 1986) have been used to differentiate between oceanic island arc, continental island arc, active continental margin and passive margin settings (Fig.7). Most samples of Al Bauga sediments plotted out of fields.

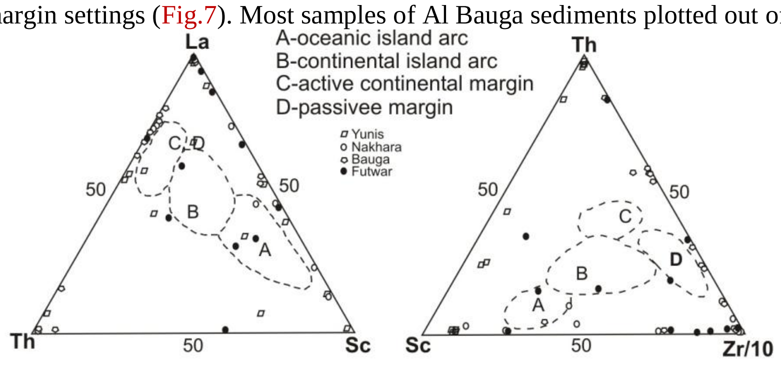

Fig.(7): Tectonic discrimination diagram of Al Bauga sediments La-Th-Sc and Th- Sc-Zr/10 (Bhatia and Crook, 1986).

VI. Conclusion

Geochemical signatures of basin clastic sedimentary rocks provide important sources of information. In particular the use of immobile major and trace elements that are thought to be carried in the particulate load have been found to be useful indicators of source terrain, weathering, tectonic, and environmental evolution. Trace elements are relatively insoluble and as a result, their original compositions are not upset during the sedimentary processes (Taylor and McLennan, 1985; Cullers, 1994). The major element geochemistry of sandstones can be used for drawing inferences related to the provenance type and the plate tectonic setting of ancient sedimentary basins (Armstrong—Altrin, et al., 2004; Roser and Korsch, 1986). Discriminant diagrams for tectonic setting and provenance used in this paper placed the majority of Al Bauga sediments within the passive margin (PM) setting and very limited Oceanic island arc of felsic igneous provenance as a dominant source area.

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