



ISSN 2314-5609  
Nuclear Sciences Scientific Journal  
6, 111-122  
2017  
<http://www.ssnma.com>

## THE APPLICATION OF GEOCHEMICAL AND MINERALOGICAL STUDIES OF CRETACEOUS SHALES IN WEST SIBAIYA AREA, EGYPT TO INVESTIGATE THEIR TECTONIC AND SEDIMENTOLOGICAL ORIGIN WITH ENVIRONMENTAL IMPACTS

IBRAHIM H. ZIDAN and RAMAG A. OSMAN  
*Nuclear Materials Authority, Cairo, Egypt*

### ABSTRACT

Sibaiya area is located at the southwestern corner of the Qena bend, Nile Valley, Egypt. The area is covered by Campanian to Maastrichtian rocks composing a number of shale layers in three formations. The present investigation comprises insights in the geochemical composition and clay minerals included in the Cretaceous shale-bearing sediments in Sibaiya west. Fifteen representative trench samples were collected from a vertical lithostratigraphic section including all the geological formations (Qusir Shale Member of Nubia Formation, Duwi Formation and Dakhla Formation) in present area. They were subjected to mineralogical and chemical analyses using modern methods and application of the proper techniques of data processing and analyses.

The data were utilized to investigate the tectonic province of the source rock of Sibaiya shales by displaying the analyzed  $\text{SiO}_2\%$  against  $\log (\text{K}_2\text{O}/\text{Na}_2\text{O})$  on the tectonic discrimination diagram. This application obviously indicated that the source rock is of the arc tectonic province. In order to confirm this origin, trials were also made to construct an upper crust normalization pattern of Sibaiya shale-bearing sediments using the chemical analyses of major and trace elements. The diagram obviously indicates that the tectonic province of the source rock cannot belong to the upper continental crust (UCC). In addition, the display of the  $\text{TiO}_2\%$  against the  $\text{Al}_2\text{O}_3\%$  diagram and correlation with the UCC, basalt and other global shales, of known tectonic origin, has also indicated that the origin of Sibaiya shales is comparable with basalt. This also supports a more basic source and infers an arc province origin. The immobile element values, specially the relatively higher values of trace elements (Cr, V, Ni and Ti) provide a strong evidence that supports a basic origin of Sibaiya shales and also suggests a dominance of mafic volcanic source in general, whilst, the high V/Cr and Ni/Cr ratios, in particular, may indicate that the investigated sediments were deposited under oxidizing environment.

Both the geochemical indices and the geochemical ratios reveal that there are no obvious differences between the distribution of major and trace elements in most Campanian to Maastrichtian shales in Sibaiya. This pattern of distribution suggests a single chemical clan and most of the investigated sediments are related mainly to the same rock source which is dominated by mafic volcanic rocks. Therefore, the tectonic setting studies indicated that the investigated Sibaiya shales were derived mainly from mafic volcanic source rocks, most probably the Eastern Desert of basaltic and andesitic rocks.

The study of the weathering trends and chemical mobility was also undertaken using the chemical and mineralogical analyses. In this respect, the chemical Index of alteration (CIA) was calculated for all the samples and revealed that Sibaiya shales describe low to moderate chemically weathered terrain. Beside, the fluviatile of post deposition contributions from local sources, such as the basement rocks in the

Egyptian Eastern and Western deserts, can be considered as subordinate sources. This is represented by the relative abundance of kaolinite in the clay minerals.

Additional environmental investigations were also undertaken in order to explore any environmental radiation impact that may arise from the utility of these shales in any domestic purposes by the locals and/ industry. The calculation of geo-accumulation index in Sibaiya shales was used to study the pollution pattern and revealed that these shales describe a low to moderate polluted terrain. However the dilution factor when mixed with other material during domestic utility may make it an environmentally safe product.

## INTRODUCTION

The investigated area lies between long.  $32^{\circ} 38' 15''$ -  $32^{\circ} 38' 25''$  E and lat.  $25^{\circ} 10' 43''$ -  $25^{\circ} 10' 50''$  N, southwestern side of Qena bend, Nile Valley (Fig. 1). The stratigraphic succession is of Campanian-Maastrichtian age and represents a part of the dominated sedimentary deposits of variegated and black shales that are widely distributed in Upper Egypt. This succession laterally extends from the New Valley in the Western Desert to Safaga-El Quseir region on the Red Sea Coastal plain through Sibaiya at Nile Valley.

Sibaiya area contains occurrence of extensive black shale beds of Duwi Formation that overlie a fluvial variegated shale sequence in Quseir Member of Nubia Formation, with an undulating erosion contact Zidan(2002). The entire succession is conformably overlain by the deeper marine laminated grey to black shales of the Dakhla Formation.

The present study aims to investigate the source provenance, the degree of chemical weathering, and any pollution that may arise from Sibaiya shales, when used in domestic purposes. This purpose can be achieved by studying the clay mineralogy, the geochemical characters of some Campanian-Maastrichtian shales, collected from a composite section, located at Sibaiya area, West Valley.

In order to attain this purpose, 15 representative trench samples were collected from an exposed vertical stratigraphic section. They used to describe all the exposed layers in the entire succession. These samples were subjected to mineralogical and chemical

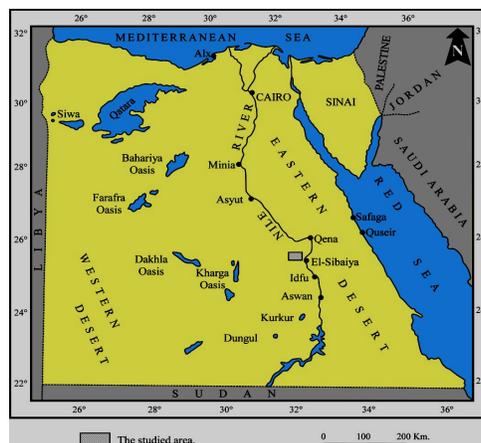


Fig. 1: location map of the studied Sibaiya area, west Nile Valley

analyses to investigate their characteristics paying special attention to the determination of their contents of radioactive elements and rare earth elements.

## GEOLOGIC SETTING

The stratigraphic succession in Sibaiya area, southwest of the Nile Valley, was previously described by Issawi et al (1999). From field observations, the exposed lithostratigraphic section based by Quseir shale Member of Nubia Formation and then overlain by the Duwi Formation and Dakhla Formation at the top (Fig. 2).

The Quseir shale Member is composed of different variegated shales, reddish brown, grey and yellow in colour. The Duwi Formation composes Lower Phosphorite Member

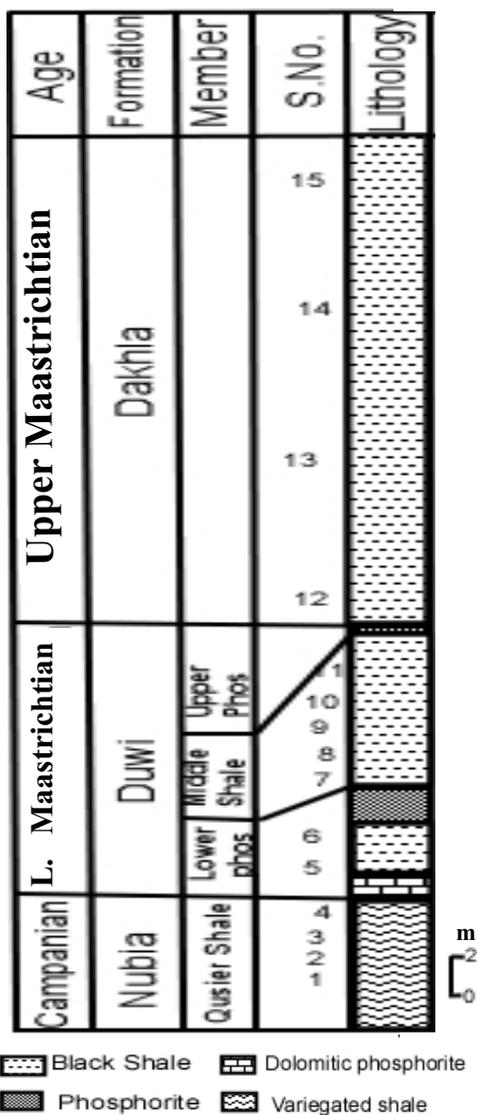


Fig.2: Lithostratigraphic section of Sibaiya area, west Nile Valley and sample locations

represented by an oxidized phosphorite bed intercalated with thin lenses of grey shales of thickness ranging between 0.2–0.6m averaging 0.4m and the Middle Shale Member is mainly composed of gray shale, cracked and

filled with gypsum. Meanwhile the Upper Phosphorite Member is composed of thin phosphatic bed. Zidan (2002) reported that the Duwi Formation is unconformably overlying the Qusseir Shale Member with an undulating surface. The Dakhla Formation at the top, is composed of grey to black shale, papery, cracked and filled with gypsum and ferruginous stains and has thickness ranging between 10m and 30m averaging 20m. Obviously, the deposition represents an initial stage of the late Cretaceous marine transgression in Egypt. The precise age of the Duwi Formation is still debatable, however it is generally considered as either late Campanian to early Maastrichtian based on paleontological evidences (Glenn and Arthur, 1990).

### SAMPLING AND ANALYTICAL TECHNIQUES

A total of 15 representative samples of variegated and black shales were collected from a vertical stratigraphic section representing all the formations and members at Sibaiya area. Each sample was subjected to the relevant proper sample preparation required for the mineralogical and/or chemical analyses. Nine representative samples were subjected to mineralogical analysis using XRD. The operations of sample preparation and analyses were professionally undertaken in the laboratories of the Nuclear Materials Authority of Egypt (NMA). The major oxides were determined using wet chemical technique, whilst the trace elements were analyzed using the X-ray fluorescence. Uranium and thorium contents were determined radiometrically using gamma-ray spectrometer; also U was chemically determined using a spectrophotometer analysis. The REEs were determined using the ICPOES technique.

### Mineralogical and Chemical Data presentation

Kaolinite, Montmorillonite and illite are the dominant clay minerals in the studied shales. Accordingly, the analyses of 9 samples

out of the 15 original samples are sufficient to describe the clay mineralogy included in the shale samples of Sibaiya lithostratigraphic section. (Fig.3) shows the XRD patterns of only one representative sample from each formation.

### Mineralogical and Geochemical Analysis and Interpretation

The mineralogical and chemical laboratory analyses of Sibaiya shale samples were first subjected to the proper data reduction and processing techniques, and the final

chemical results are presented in Tables 1 & 2. Whilst, the main constituents of clay minerals in the investigated Sibaiya shales are Kaolinite, Montmorillonite and illite as revealed by the XRD chart sample (Fig.3). Kaolinite considered being dominant in fluvial environments. In the present study the dominance of kaolinite beside montmorillonite, suggests that these minerals are probably due to contributions from local source, by inheritance from kaolinitized source rocks. Aeolian contribution from the Western Desert makes kaolinite a common constituent that cannot be excluded.

### BASIS OF THE PRESENT INVESTIGATIONS

The sedimentary formations in Sibaiya are composed mainly of derivatives originated from other older rock source in a major province that have suffered different kinds of weathering and transportation. However, post depositional tectonic evolution, in addition to relatively minor lithological contributions from local and surrounding sources took place and resulted in contemporaneous or even younger intercalations and/or alterations.

The present study aims primarily to investigate; the probable source rock provenance, the weathering trends and intensity, the evolution of tectonic setting and the environmental aspect of sibaiya. Throughout the present work, modern international concepts of such investigations are widely utilized as an interpretation guide supported by international examples

The provenance determination, the main concepts and basics utilized throughout the present investigations are according to Taylor and McLennan (1985), Singh et. al. (2005) and Abou El-Anwar and Samy (2013). In addition a comparison between the chemical composition of Sibaiya shales and some other global shales of known origin was held in order to support the present investigations of the provenance determination and weathering history.

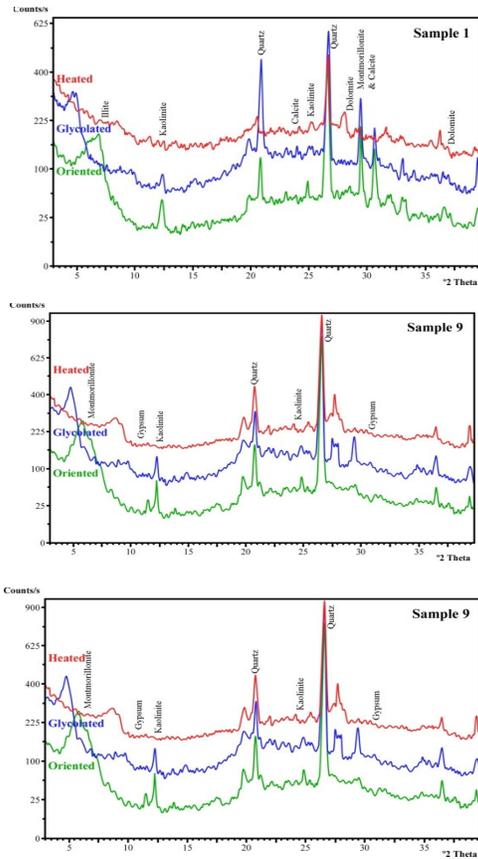


Fig.3: Examples of the X-ray diffraction patterns of the variegated and black shale samples in Sibaiya area, West Nile Valley

Table 1: Major oxides (Wt%) and trace elements (ppm) in different shale samples, Sibaiya area, West Nile Valley

Sample No.	Qusier Shale Member				Duwi Formation							Dakhla Formation			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SiO <sub>2</sub>	50	51	53	54	49	49	50	48	51	47	49	50	47	51	51
TiO <sub>2</sub>	0.6	2.3	0.2	2	0.2	1.5	1	1.2	0.2	0.2	1	1.8	1	2	1.5
Al <sub>2</sub> O <sub>3</sub>	14	12.5	13.7	14.5	12	13	14	13	13	14	13	14	14	14.5	13
Fe <sub>2</sub> O <sub>3</sub>	2.7	2.2	5.6	2	13	11	9	12	12	12	13	10	11	10	10.5
P <sub>2</sub> O <sub>5</sub>	2.5	3.2	2.5	3.1	3.5	3	4.3	2.5	2	2.1	2	2.4	2.2	2	2
MgO	0.4	1.2	1.3	0.5	0.5	0.2	0.4	0.2	1	1.5	1.3	1	1.3	1	1
CaO	6	6.5	5.5	6	6	6.5	5	4	4	4.5	5.2	5	4.5	5	5
Na <sub>2</sub> O	1.5	1.7	1.6	1.2	1	1	0.8	2	1	1	1	1	1	2	1
K <sub>2</sub> O	4.3	4.9	2.8	4.7	1.5	2.5	1	1	2	2	1.9	1.5	1.3	1.8	2
MnO	0.3	0.2	0.3	0.4	0.2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.01
L.O.I	16	14.5	14.2	12	14	13	14	15	14	15	12	14	15	11	13
Total(%)	99	100	100	100	100	100	99	99	100	99	99	100	99	100	100
CIA.%	66	60	70	67	77	74	84	72	76	78	77	80	81	71	76
Trace elements															
Cr	111	120	112	120	161	157	107	123	148	165	176	137	128	146	127
Ni	23	25	24	25	55	57	40	43	53	57	57	52	45	57	43
Cu	33	35	33	36	29	29	30	27	27	36	36	37	36	33	31
Zn	67	68	67	69	189	182	91	172	149	163	154	162	136	156	126
Rb	76	75	81	74	52	39	74	33	44	97	95	66	63	87	58
Y	114	111	123	103	25	20	12	15	19	34	29	48	41	45	35
Ba	1507	1628	1547	1608	766	595	556	590	746	1329	1625	1260	1260	1276	1097
Pb	10	15	20	14	24	15	13	14	25	15	19	26	14	16	13
Sr	407	402	447	372	108	90	46	66	87	120	97	176	151	161	127
Ga	6	7	7	8	9	7	11	6	7	7	8	9	7	5	6
V	161	173	166	171	128	100	86	94	140	180	223	165	149	166	141
Nb	53	51	58	48	13	10	5	8	10	15	13	22	19	21	17
REEs	209	152	179	200	650	605	840	680	464	450	440	460	449	127	441
Cr/Ni	4.8	4.8	4.7	4.8	2.9	2.8	2.7	2.9	2.8	2.9	3.1	2.6	2.8	2.6	3
V/Ni	7	6.9	6.9	6.8	2.3	1.8	2.2	2.2	2.6	3.2	3.9	3.2	3.3	2.9	3.3
V/Cr	1.5	1.4	1.5	1.4	0.8	0.6	0.8	0.6	0.8	0.8	1.3	1.2	1.2	1.14	1.11
Ti/Al	0.1	0.4	0.03	0.3	0.04	0.3	0.2	0.2	0.03	0.03	0.2	0.3	0.2	0.3	0.3

Table 2: Comparison of average chemical composition of the studied Sibaiya shales with average shales and regional average composition

Formation	Qusier Shale Member	Duwi Formation	Dakhla Formation	UCC	PAAS*	NASC**	APBS	AJBS
SiO <sub>2</sub> %	52	49	50	66	62.4	64.82	8.5	6.92
Al <sub>2</sub> O <sub>3</sub> %	14	13	14	15.2	18.78	17.05	2.9	1.98
Fe <sub>2</sub> O <sub>3</sub> %	3	11	11	4.5	7.18	5.7	1.2	1.12
CaO %	6	5	5	4.2	1.29	3.51	32.3	40.7
Na <sub>2</sub> O %	1.5	0.8	1.2	3.9	1.19	1.13	n.a.	0.04
K <sub>2</sub> O %	4	1.7	1.6	3.4	3.68	3.97	n.a.	0.04
MgO %	0.8	0.7	1	2.2	2.19	2.83	0.6	0.99
TiO <sub>2</sub> %	0.8	0.6	1.5	0.5	0.99	0.8	0.1	0.15
CIA %	67	79	78	57.58	75.60	73.24	n.a.	94.29
Cr ppm	116	148	135	35	110	125	256	305
Ni ppm	24.25	51.71	49.25	20	55	58	136	594
Cu ppm	34.25	30.57	34.25	n.a.	50	n.a.	83	60
V ppm	167.75	135.86	155.25	60	150	130	78	78
REEs ppm	185	590	440	146.37	184.8	154.5	n.a.	n.a.
Cr/Ni	4.77	2.86	2.73	1.75	2	2.16	1.88	0.51
V/Ni	6.92	2.63	3.15	3	2.73	2.24	0.57	0.13
V/Cr	1.45	0.92	1.15	1.71	1.36	1.04	0.30	0.26
Ti/Al	0.21	0.14	0.27	0.07	0.12	0.11	0.08	0.17

\*average 23 post-Archean shales from Australia; UCC: Upper Continental Crust Taylor & McLennan (1985); \*\*: Composite 40 shales, mainly N.American Gromet et al. (in Nyakairu and Koerber, 2001); APBS: Average Palestinian black shales Ahmed; AJBS: Average Jordanian black (oil) shales Abed and Amireh (in Temraz, 2005). n.a.: not available

### DETERMINATION OF THE PROVENANCE AND TECTONIC SETTING

The type of the provenance of shales in Sibaiya area depends largely upon its position to an adjacent tectonic settings and the comparison between their chemical compositions with those of sediments deposited in this known tectonic settings. Roser and Korsch (1988) proposed a tectonic classification based on  $\text{SiO}_2$  content and  $\log(\text{K}_2\text{O}/\text{Na}_2\text{O})$  ratios as described in (Fig.4) dividing the tectonic origin into three provinces. The application of this classification to Sibaiya shales indicates that these ratios fall in the field of arc of provenance except one sample from Qusier Shale Member which falls in active continental margin, this indicate the Sibaiya shales are mainly derived from felsic volcanic rocks. In order to support this classification the following tests were applied using the upper continental crust normalization pattern and the immobile elements correlation with the UCC.

#### Upper crust normalized pattern

Concentrations of the major and trace elements of the investigated shale samples have been normalized to the average Upper Continental Crust (UCC) values Taylor and McLennan (1985). The UCC normalized pattern for the studied samples (Fig. 5) can be classified into three classes:

-The first class comprises elements being dominant relative to the UCC (e.g. Cr, U, Ni, V and Ba). The dominance of most of these elements may be attributed to the occurrence of mafic components in the source rocks. However, the relative abundance of K than UCC is attributed to the abundance of illite mineral.

-The second class comprises the major elements, CaO, MgO and  $\text{Na}_2\text{O}$ . These elements are relatively lower compared to the UCC values. These elements are susceptible to mobility during weathering processes due to their

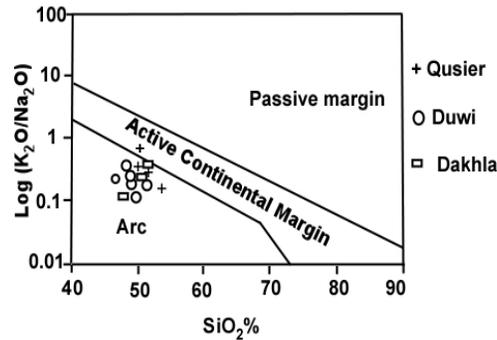


Fig. 4: Tectonic discrimination diagram for the Sibaiya shale samples. Lines are placed according to Roser and Korsch (1988)

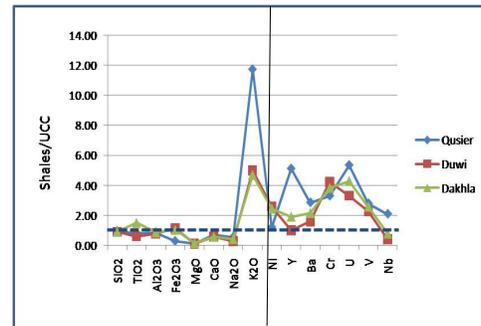


Fig.5: UCC normalized for major and trace studied elements of Sibaiya shale samples

high hydration energies Cullers (2000).

-The third class consists of  $\text{SiO}_2$ ,  $\text{TiO}_2$ ,  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  (excepted in Qusier Shale Member) in which the concentrations of these elements in the investigated samples are more or less similar that in the UCC. This may be due to the efficient mixing of sedimentary material during weathering of the source rock, transportation and deposition in the study area. Therefore the UCC origin of the provenance is not recommended and a shift towards a more basic tectonic origin is strongly recommended.

### PROVENANCE AND IMMOBILE ELEMENTS

Singh et al. (2005) indicated that the geochemical composition of siliclastic sediments results from a complex interplay between provenance and processes that operate during the different stages of the sedimentary cycle. In addition, the immobile elements are also indicators of the origin of the provenance. Therefore, the presence of trace elements Cr, V and Ni in addition to Ti suggests a basic origin of Sibaiya shales. This conclusion was confirmed by Taylor and McLennan (1985). (Table 2) shows that the average values of  $TiO_2/Al_2O_3$  ratios for most of the investigated sediments lie around a value (0.21), which is similar to that of basaltic source and higher than the corresponding values for UCC, NASC, and PAAS (Fig.6).

In addition, the analyzed samples show high relative abundance of Cr, U, Ni, V and Ba elements. This may be attributed to the presence of mafic components in the source rocks. Also the analyses revealed higher K values than upper continental crust (UCC) due to the relative abundance of illite mineral. Relative high values were also obtained in the geochemical ratios of V/Cr, Cr/Ni and V/Ni in almost all the analyzed samples collected from the studied formations. This may reveal a dominance of mafic volcanic source. In general, whilst, the high V/Cr and Cr/Ni ratios, in particular, may also reveal that the investigated sediments were deposited under oxidizing environment. All the previous information confirms that the original source rock of Sibaiya shales is of mafic to ultramafic nature of tectonic arc province. It is such tectonic province Egyptian Eastern Desert.

### CHEMICAL MOBILITY AND WEATHERING TRENDS

The chemical composition of the various weathering products depends largely upon the rate of weathering and it is expected to demonstrate well established concepts of mo-

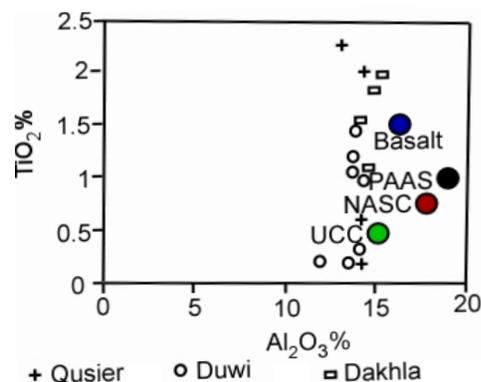


Fig. 6: Relationship between  $TiO_2$  and  $Al_2O_3$ % for; average values Sibaiya shale samples compared with that of UCC, NASC and PAAS

bility of various elements during weathering and therefore to assess the state of chemical weathering Singh et al. (2005). The preferential removal of  $CaO$ ,  $Na_2O$  and  $K_2O$  by solution during weathering processes Nesbitt and Young (1989) due to their high mobility. It means that the abundance of these elements with respect to less easily removed elements can be used as a measure of the extent of chemical weathering in provenance. Since Al in feldspars is the least mobile element, Nesbitt and Young (1989) proposed a chemical index of alteration (CIA) where:

$$CIA = [Al_2O_3 / (Al_2O_3 + CaO^* + Na_2O + K_2O)] \times 100.$$

The value of CIA is obtained by direct substitution in this equation from the chemical analyses except the value of  $CaO^*$ .  $CaO^*$  represents  $CaO$  associated with the silicate fraction of the sample.  $CaO^*$  is equal to  $Na_2O$  values when  $CaO > Na_2O$ , and equals to the  $CaO$  values when it is  $\leq Na_2O$ . Therefore the  $CaO^*$  values are equal to the corresponding  $Na_2O$  values the studied samples Liu et al. (2009).

The CIA enables the estimation of the intensity of weathering in the sedimentary deposits, or it may be used to compare the relative proportions of chemically weathered material

present in a sample. According to Nesbitt and Young (1989); CIA value of 50-60 reflects a weak chemical weathering degree, while CIA ranges from 60-80 indicates moderate degree of weathering and CIA value of 80-100 means intensive weathering. In the investigated samples of Qusier Shale member, Duwi and Dakhla Formations, the recorded CIA average values are 67%, 79% and 78%, respectively (Table 2). Which they indicated that the investigated shales of studied formations have relatively suffered low to moderate chemically weathered provenance.

Kaolinite is generally produced by feldspars alteration. It requires an open and acidic environment, with extensive leaching of alkaline earths and ferrous ions and to some extent silica from the medium during the process Weaver (1989). Floyd et al. (1989) have generally made kaolinite a common constituent that cannot be excluded. The origin of kaolinite in the Sibaiya shales has been interpreted, for a long time, as a product of chemical weathering of feldspars. Kaolinite formation is favoured under tropical to subtropical humid climatic conditions Hallam et al. (in Temraz, 2005). In addition to its detrital origin, kaolinite may also be developed by diagenetic processes due to the circulation of acid solutions (Temraz, 2005). These kaolinites are believed to represent a continental weathering product at a warm and at least seasonally humid climate, being eroded and transported towards the sea by rivers.

The radiometric eU content of Sibaiya shale samples ranges between 2 and 17ppm with an average of 8ppm, while chemically it attains a value between 3 ppm and 18 ppm with an average 12ppm (Table 3). The (cU/Th) ratios at investigated shales (Table 3) indicate higher degree of uranium mobilization and (deposition) enrichment. The equilibrium factor P-Factor (eU/Ra) was more than one, indicating a possible (deposition) enrichment of uranium in a disequilibrium state (Naumov, 1959). Also, these results were confirmed by the calculation of D-Factor (cU/eU) which is mainly more than one showing distinct disequilibrium state with the addition of (younger) uranium youngest (emitting) gamma-ray (Adams and Weaver, 1958).

#### GEO-ACCUMULATION INDEX AND POLLUTION PATTERN

The index of geo-accumulation (Igeo) proposed by Müller (1969) has been used widely to assess of soil and sediment contamination Loska et al. (2004) and Graver et al (1996). This index is computed using the following equation:  $I_{geo} = \log_2(C_n/1.5B_n)$ . Where  $C_n$  is the measured concentration of a given metal in sediment and  $B_n$  represents the geochemical background concentration of it.

Under normal environmental conditions, the natural concentrations of elements in sediments have a usual characteristic pattern of distribution. However, the environmen-

Table 3: Radiometric analysis (ppm) of Sibaiya shale samples, West Nile Valley

Sample No.	Qusier					Duwi					Dakhla					Aver.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
eU	11	11	8	16	5	7	7	3	17	4	2	8	7	8	8	8
eTh	9	11	12	1	7	6	3	3	6	8	11	1	10	9	8	6
Ra	2	4	4	4	5	2	3	4	10	4	2	6	2	4	2	4
cU	14	16	12	18	8	11	10	7	18	8	3	12	11	13	12	12
cU/eTh	1.3	1.4	1.	18	1.1	1.8	3.3	2.3	3	1	0.3	12	1.1	1.4	1.5	2
cU/eU	1.3	1.4	1.5	1.1	1.6	1.6	1.4	3.5	1	2	1.5	1.5	1.6	1.5	1.5	1.5
eU/Ra	5.5	3	2	4	1	3.5	3.5	0.8	1.7	1	1	1.3	3.5	2	4	2

tal pollution by domestic, agricultural, and industrial wastes and also the natural input cause an abnormal concentration of some of the major and trace elements contents in a sediment and consequently disturb these natural relationships. The disturbance of the natural geochemical patterns of association accompanied by mineralogical and textural differences may indicate an anthropogenic or natural input. In the present study the concentrations of elements in the UCC Taylor and McLennan (1985) were used as background values. According to Müller (1969) the geo-accumulation index in relation to pollution extent is classified into seven classes (Table 4).

In Sibaiya shale samples the results of geo-accumulation index of the Qusier Shale Member, Duwi and Dakhla Formations show that the V content (0.9, 0.6 and 0.78, respectively) and Ba (0.93, 0.1 and 0.54, respectively). Therefore they are classified as unpolluted to moderately polluted elements. On the other hand, Ni in Duwi and Dakhla is (0.79 and 0.71, respectively) reveal a moderately polluted element. Average of Cr at Qusier Shale Member, Duwi and Dakhla Formations is (1.14, 1.5 and 1.36, respectively) while U content in the same shales are (1.84, 1.15 and 1.51, respectively). Cr and U are the elements being considered as moderately polluted element (Table 4).

Even Y at Qusier Shale Member is mod-

erately polluted element. It can be concluded that, the shales of Sibaiya area are classified generally as unpolluted to moderately polluted region.

The recorded moderately polluted characters recorded in the investigated samples are most probably attributed to the natural weathering of the source rocks rather than artificial input. The relative abundance of Cr is most probably due to substitution of Cr by iron in the structure of the ferromagnesian silicate minerals. The industrial and the agricultural wastes are nearly absent in the study area since it occurs in remote desertic area and therefore, it is suggested that the anthropogenic input is rather limited.

Prudêncio et al. (1989) suggested that kaolinite, among the clay minerals, tends to be the principal REEs carrier in the clay fraction of sediments from central Portugal. The distribution of REEs in sediment depends on their concentrations in the source rocks and on the partitioning behavior of the REEs between the fluids and the mineral phases of these rocks. The changes taking place during transportation and after the deposition can be also considered. Adams et al. (1959) reported that the shale bed is the most suitable lithological facies for uranium trapping, adsorption, fixation, substitution and capturing as a result of the presence of clay minerals, organic matter and iron minerals.

Slansky (1986) reported that, Sea water

Table 4: The geo-accumulation index (Igeo) of Sibaiya shales, West Nile Valley

Range (ppm)	Degree of pollution	Average elements in the studied area		
		Qusier Shale Member	Duwi Formation	Dakhla Formation
< 0	Unpolluted	Ni, REE	Nb, Y	Nb
0 - 1	Unpolluted to moderately polluted	Nb, Ba, V	Ni, Ba, V	Ni, Y, Ba, V, REE
1 - 2	Moderately polluted	Y, Cr, U	U, Cr, REE	U, Cr
2 - 3	Moderately to strongly polluted	-	-	-
3 - 4	Strongly polluted	-	-	-
4 - 5	Strongly to very strongly polluted	-	-	-
> 5	Very strongly polluted	-	-	-

is the essential source of uranium in marine sediments in the form of dissolved  $U^{+6}$  linked to a carbonate complex. The main uranium compounds in phosphorites are  $U^{+4}$  and  $U^{+6}$ . The tetravalent form replaces partially  $Ca^{+2}$  in apatite because their similar ionic radii, while the hexavalent one is enriched in the ore by adsorption onto mineral surface. Lucas et al. (1980) suggested the trace elements in phosphorite may be present in the apatite lattice or fixed in/or clays.

### CONCLUSIONS

Kaolinite and montmorillonite constitute the main clay minerals of the investigated Sibaiya shales. XRD reveal that the investigated clay minerals are mainly detrital in origin. There is a general correspondence in the proportions of the studied clay minerals with which derived from a common parent rock with little contamination from other sources.

The chemical analyses indicated that the studied clay sediments are dominant in U, Ba as well as ferromagnesian trace elements Cr, Ni and V. The relative abundance of most elements suggests that the studied formations derived from mafic rock source constitute their source. The ratios V/Cr, Cr/Ni and V/Ni support that the source rock of mafic volcanic type. The depletion of Ca, Na and Sr indicate high mobility during weathering. V/Cr ratios revealed that the examined clay sediments were deposited under oxidizing condition. The chemistry of the studied clay sediments indicated that these clays are derived from mafic source. The geo-accumulation indices (Igeo) indicate that the investigated sediments in Sibaiya area are mainly low to moderately pollute. However their utility in domestic purposes is safe if the dilution factor in the final product is proper.

Sediment composition indicates the tectonic setting of source rock referring to passive margin for Sibaiya samples and lie between passive margin and active continental mar-

gin. The chemical indices of alteration (CIA) reveal that the studied shales of Sibaiya area are low to moderate chemically weathered provenance.

The geochemistry and the clay mineral assemblages in the studied shales reveal that these are most probably derived from the Egyptian Eastern Desert composed mainly of basic volcanic rocks. Moreover, the fluvial origin, partial aeolian contribution of kaolinite from the Western Desert taken into consideration as a subordinate source.

### Acknowledgements

The authors wish to express their great thanks to Prof. Dr. H.S.Sadek for his critical reviewing and discussions during performing constructive this work.

### REFERENCES

- Abou El-Anwar, E. A., and Samy, Y. M., 2013. Clay Mineralogy and Geochemical Characterization of Some Quaternary Sediments on Giza-Fayyum District, Western Nile Valley, Egypt: Relationships to Weathering and Provenance. *J. Appl. Sci. Research*, 9(8),4765-4780.
- Adams, J. A. S., and Weaver, C. E., 1958. Thorium to uranium ratios as indicators of sedimentary example of the concept of geochemical faces. *Bull. Am. Ass. Petrol. Geol.*,42, 387 -430.
- Adams, J. A. S.; Osmono, J. K., and Rogers, J. J. W., 1959. The geochemistry of uranium and thorium. *Phys.Chem. Earth*, 3, 298.
- Cullers, R..L., 2000. The geochemistry of shales, siltstones and sandstones of Pennsylvanian-Permian age, Colorado, USA: implications for provenance and metamorphic studies, *Lithos*, 51,181-203.
- De Baar, H. J. W.; Bacon, M. P.; Brewer, P. G., and Bruland, K. W.,1985. Rare earth elements in the Pacific and Atlantic Oceans. *Geochimica et Cosmochimica Acta*, 49,1943-1 959.
- Floyd, P.A.; Franke, W., Shail, R., and Dorr, W.,1989. Geochemistry and tectonic setting of

- Lewisian clastic metasediments from the Early Proterozoic Loch Maree Group of Gairloch, NW Scotland. *Precam. Res.*, 45, 203-214.
- Garver, J. I.; Royce, P. R., and Smick, T. A.,1996. Chromium and nickel in shale of the Taconic Foreland: A case study for the provenance of fine-grained sediments with an ultramafic source, *J. Sed. Res.*, 66, 100-106.
- Glenn, C. R., and Arthur, M. A.,1990. Anatomy and origin of a Cretaceous phosphorite-green sand giant, Egypt. *Sedimentology*, 37, 123-154
- Isawi, B.; El Hinnawi, M.; Francis, M., and Mazhar, A.,1999. The phanerozoic geology of Egypt. Ageodynamic approach, special Pub No.76. Geol. Survey. Cairo. Egypt.
- Liu, Z.Z.; Yulong, C.; Colin, P.; Fernando, C. , Siringan, and Wua, Q. ,2009. Chemical weathering in Luzon, Philippines from clay mineralogy and major-element geochemistry of river sediments, *Applied Geochemistry*, 24, 2195-2205.
- Loska, K.; Wiechula, D., and Korus, I.,2004. Metal contamination of farming soils affected by industry. *Environment International*, 30, 159-165.
- Lucas, J.; Flicateateaux, R.; Nathan, Y.; Prevot, L., and Shahrar, Y.,1980. Different aspects of the phosphorite weathering- sepm spec. *Publ.*, 31-40, Tulsa.
- Müller, G.,1969. Index of geoaccumulation in sediments of the Rhine river. *Geo. J.*, 2, 108-118.
- Naumov, G. B.,1959. Transportation of uranium in hydrothermal solution as carbonate. *Geoch.*, 1, 5-20.
- Nesbitt, H.W., and Young, G.M.,1989. Formation and diagenesis of weathering profiles, *J. Geology*, 97, 129- 147
- Nyakairu, G. W. A., and Koeberl, C.,2001. Mineralogical and chemical composition and distribution of rare earth elements in clay-rich sediments from central Uganda. *Geochemical J.*, 35, 13 - 28.
- Prudêncio, M. I.; Cabral, J. M. P., and Tavares, A.,1989. Identification of clay sources used for Conímbriga and Santa Olaia pottery making, in *Archaeometry: proceedings of the 25<sup>th</sup> Inter. Sym. (Maniatis, Y., Ed.)*. Elsevier, Amsterdam. 503 – 14.
- Roser, B. P., and Korsch, R. J.,1988. Provenance signatures of sandstone- mudstone suite determined using discriminate function analysis of major element data. *Chem. Geol.*, 67, 119-139.
- Singh, M.; Sharma, M., and Tobschall, H. L.,2005. Weathering of the Ganga alluvial plain, northern India:implications from fluvial geochemistry of the Gomati River. *Appl. Geochem.*, 20, 1-21.
- Slansky, M.,1986. *Geology of Sedimentary Phosphates*. North Oxford Academic Publishers. London. 210 p.
- Taylor, S. R., and McLennan, S. M.,1985. The Continental Crust: Its Composition and Vietnam in the western South China Sea: Implications for source analysis and East Asian monsoon evolution. *Sci. China Ser. D Earth Sci.*, 50, 1674-1684.
- Temraz, M., 2005. *Mineralogical and Geochemical Studies of Carbonaceous Shale Deposits from Egypt*. M.Sc.,Thesis, Bauingenieurwesen und Angewandte Geowissenschaften der Technischen Universität, Berlin.113p.
- Weaver, C.E.,1989. *Clays, Mud, and Shales*: Amsterdam, Elsevier, 819.
- Zidan, I. H., 2002. *Geological, Mineralogical and Geochemical studies of Abu Tartur Area, Western Desert, Egypt*. ph.D. Al Azhar Univ., 235p.
-

## دراسات جيوكيميائية ومعديية على طفلات العصر الطباشيرى بمنطقة السباعية غرب للتحقق من مصدرها والتأثير البيئى لها

ابراهيم هاشم زيدان و رماج احمد عبد الحميد عثمان

أثبتت الدراسة أن منطقة السباعية غرب تحتوى على طفلات متنوعة تابعة لتكوينات الداخلة والضوى وعضو القصير التابع لتكوين النوبيا . والدراسات المعديية أثبتت أن هذه الطفلات تتكون أساسا من معادن الكاولينيت ، المونتمورلونيت والاليت.

من ناحية أخرى الدراسات الجيوكيميائية أثبتت أن طفلات منطقة السباعية غرب تحتوى على عناصر أرضية نادرة وكذلك عناصر مشعة وثقيلة منها اليورانيوم ، الكروم ، النيكل ، الفناديوم. كما أكدت أن مصدر هذه الطفلات هو الصخور المافية والقوق مافية. وبدراسة العلاقة بين عناصر التيتانيوم والالمنيوم أثبتت أن هذه الطفلات مشابهة لعلاقات هذه العناصر فى صخور البازلت مما يؤكد أن مصدر تكوين هذه الطفلات من صخور مافية بركانية. ودراسة معامل (Igeo) أثبتت أن تأثير العناصر المشعة والثقيلة بطفلات منطقة السباعية غرب متوسطة الى عديمة التلوث البيئى و أن هذه الطفلات تكون امنة عند أستخدامها فى الاغراض الصناعية اذا خففت بمواد اخرى.