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Pleistocene aquifer sediments at Sohag region, Nile valley, Egypt: a statistical approach

Shaymaa Rezk, Ahmed. A. Abdel Moneim, Abdallah M. Hassan, Mohamed H. Ali*

Geology department, Faculty of Science, Sohag University, Egypt

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Abstract: Well representative detrital sandy samples from the Quaternary aquifer system of the Nile River basin at Sohag area, Egypt, were collected for the geochemical and heavy minerals investigations. Multivariate statistical techniques were applied to the obtained data. Although the heavy mineral analysis is useful in determining the provenance of the siliciclastic sediments, yet the interpretation of the data is greatly improved by determining the chemical composition of the enclosed sediments. The present study revealed that many heavy mineral species show significant variations in their distribution which may be related to their provenance. Thus, as giving greater confidence in minerals identification, but geochemical analysis of the Pleistocene sediments adds precision to the evaluation of the relative contributions of the potential source ideologies. Furthermore, multivariate statistical analyses of the geochemical and heavy minerals data from the investigated well were used to clarify the relationships between heavy metals content and heavy minerals distribution. The results revealed significant positive correlation between the well depth and the sediment contents of opaques ($p<0.001$), epidote ($p<0.001$), garnet ($p<0.05$), Ti ($p<0.01$) and Cr ($p<0.01$). Opaque minerals show positive significant relationship with Ti, S and to some extent Cr and OM (organic matter). Integration of multivariate statistical techniques and mineralogical analysis discriminate the studied sediments into two distinct groups. The first group consists of the older sediments of Kom Ombo and Qena formations which extended from depths of 39 to 54m and from 55 to 89m bgl (below ground level), respectively. The second group stated as younger sediments (from 5m to 38 m in depth) which ascribed to El Ghawanim Formation. The older sediments have higher content of opaques, amphiboles, epidotes, and garnet minerals as well as a higher concentration of OM, S, Mn, Fe, Ti and Cr than the younger sediments. This work considered as an introductory to study the impact of the geochemical and mineral composition of the Quaternary aquifer sediments on the quality of drinking water extracted from similar wells in the study area.

Keywords: Geochemical - Heavy minerals - Multivariate statistical - Quaternary aquifer - Pleistocene sediments.

1 Introduction

Many literatures were dealt with the river Nile sediments including general geology, stratigraphy, sedimentology, and archaeology, *e.g*. [1, 2, 3]. However, few studies were dealt with the mineralogy of the Nile sediments of the Sohag area, *e.g*. [4, 5, 6]. On the other hand, most of the previous studies were focused on the outcrops of the sediments in general and there is no work concerning the mineralogical content of the subsurface Nile sediments in the study area. The present study deals with the heavy minerals content of the Pleistocene aquifer sediments at Soahag region.

Heavy minerals are sensitive indicators for the provenance. More than 30 transparent detrital species are of common occurrence, many of which have characteristic parageneses. Although the heavy minerals are sensitive to the processes of weathering, transportation, deposition and diagenesis, but the heavy mineral analysis is considered as a useful tool in tracing the changes in the hydrographic setting of the Nile through time [7]. The composition of heavy mineral assemblages in sandstones may be greatly influenced by processes happening during transport, deposition, and digenesis. As a result, conservative heavy mineral data may not be a reliable guide to the nature of sediment source material. Certain features of heavy mineral suites, however, are inborn directly from the source area without significant modification, such as the varietals characteristics of the individual mineral species. Where hydraulic properties vary in a stream, the heavy minerals would not be expected to be the same in all parts of the sediments deposited from the stream, on the contrasting, the suite should vary from sample to sample. But, in highly turbulent streams will almost of the heavy minerals in the bed material load be transported and these sediments can contain a representative suite of the heavy minerals available to the stream [8]. Heavy minerals estimated vary in amount and type, depending on the history of the Nilotic

* Corresponding author E-mail: Sh_montasern@science.sohag.edu.eg
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materials. In exacting, variations in amphibole, pyroxene and epidote contents are considered of greatest significance because of sensitivity of these minerals to the sources of the Nilotic materials [2]. The Proto-Nile was approximately completely dependent upon discharge from equatorial and sub-equatorial tributaries in East Africa and from local Sudano-Egyptian affluent. The modem Nile system on the contrary, is subjected by donations from the Blue Nile and the Atbara River, which drain the Ethiopian Plateau. From the precedent studies, through repeated explanation [2, 9]; [10] and [11] that the heavy mineral fraction of the sediments of the lower Nile basin consists mainly of opaque iron minerals, amphibols, pyroxene and epidotes. The most common accessory minerals are garnet, staurolite, chlorite, zircon, apatite, rutile, tourmaline and olivine. This work was undertaken to investigate the heavy mineral and some element distributions in the subsurface Quaternary Nile sediments to know the extent of their relationship with the quality of the Quaternary aquifer.

Geologic setting

The study area, Sohag Governorate, represents a part of the Nile Valley extending between latitude 26°15′00″ to 26°45′00″N and longitude 31°15′00″ to 32°00 ′00″E (Fig.1). Sohag Governorate is extending about 125 Km long. It is bordered from the north by Assuit Governorate and from the south by Qena Governorate. The Nile Valley segment within Sohag Governorate is bordered from the east and west by the highe relief Eocene limestone plateau (Thebes and Drunka formations) which is reaching up to 375 m (a.s.l.).

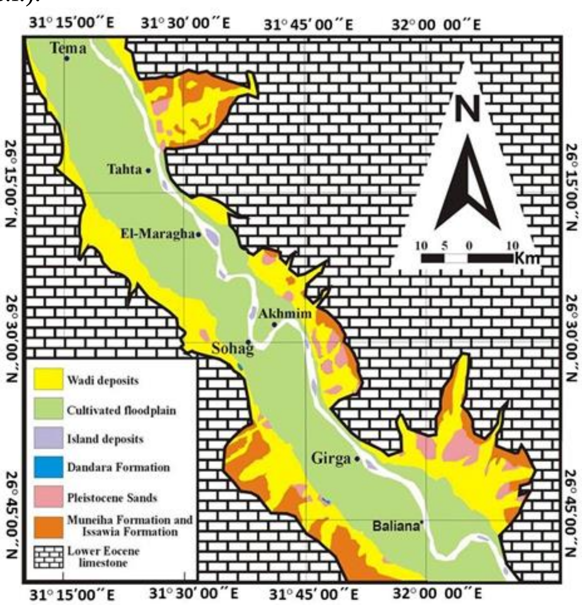

Fig. 1: Simplified geological map of Sohag governorate

The River Nile course is flowing from south northward crossing the fertile lands of the cultivated flood plain (Fig. 2). The area between the cultivated flood plain and the Eocene limestone plateau is occupied by the desert fringes including clastic sediments of Pliocene, Pleistocene and Holocene ages. The lithostratigraphic setting of the Nile sediments (Table1) has been studied in detail by many authors *e.g*., [3, 5, 6, 12, 13, 14, 15, 16, 17].

2 Materials and methods

Heavy minerals analysis

The majority of the studies approved that the heavy minerals develop in the sand fractions 0.250 -0.125 mm and 0.125- 0.063 mm. Twenty-seven representative detrital sandy samples from the Quaternary aquifer sediments from two wells at Sohag City were selected for the heavy minerals analysis and the sand fraction of 0.125 -0.063 mm was chosen for laboratory investigation.

Fig. 2(a): Simplified geological map of Sohag governorate, **(b):** Schematic geological section crossing the Nile Valley

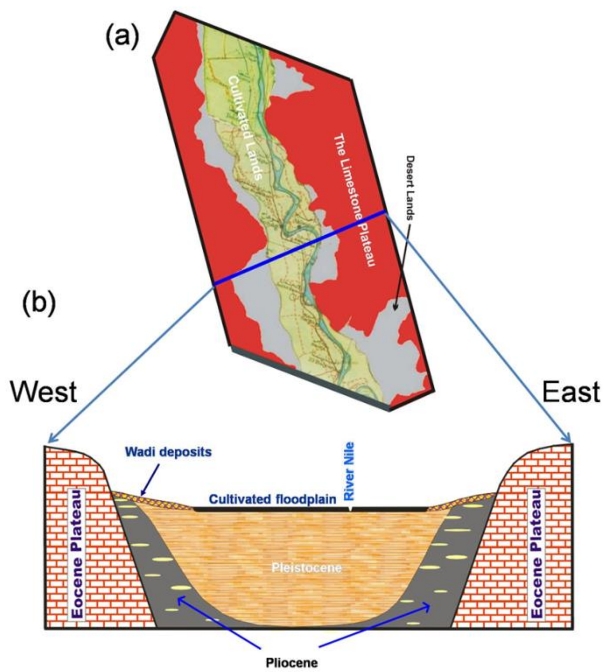

Table 1: The different rock units located in Sohag area

Period	Age	Formation
Neogene and Quaternary	Holocene	Nile flood plain
		Wadi deposits
	Pleistocene	Dandara Formation
		Ghawanim Formation
		Kom Ombo Formation
		Qena Formation
	Plio -Pleistocene	Armant Formation
		Issawia Formation
	Pliocene	Muneiha Formation
Eocene		Thebes and Drunka formations

Heavy and light minerals are separated by gravity separation in a high-density liquid [18]. Fractionation of heavy minerals from light minerals was carried out by all

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investigators using bromoform liquid. About 300 grains were usually chosen in unsystematic fields to estimate the frequency of minerals species.

Chemical analysis

In the laboratory, bulk samples were air-dried. For the determination of the total metal content, 0.5 g aliquots from the samples were transferred into Teflon beakers. The samples were acid digested with a mixture of 3 ml HNO_3 (69%), 2 ml $HClO_3$ (40%) and 10 ml HF (40%), till incipient dryness. The formed paste was dissolved with 10 ml HCl (2M) and gently heated for about 1hr till complete dissolution. Upon cooling, the solutions were made up to 25 ml with distilled water and stored at 4oc. Concentrations of the investigated metals (Fe, Mn, Zn, Cu, Pb, Cr, Ti and Cd) were measured in the different solutions by Atomic Absorption Spectrophotometer.

Data processing and computation

The obtained data have been analyzed for the cluster diagrams and the graphic presentations by using the Minitab13 for windows XP computer program distributed by StatSoft Inc.

3 Results and discussion

3.1 Heavy mineral characterization

In the present study, the obtained data are used for the heavy mineral qualification, quantification and characterization studied sediments. Interpretation of the heavy minerals in relation to the source rocks is performed and thus the heavy mineralogical examination can support the proposed lithostratigraphic statement of the present study. The heavy mineral examination of the considered sediments revealed that the studied fractions are composed of significant amounts of opaques and non-opaque heavy minerals. The non-opaque minerals include amphiboles, epidotes, pyroxenes, zircon, garnet, and staurolite, and the opaques are dominated by iron oxides.

3.1.1 Opaque minerals

The identification of the opaque mineral types needs a separate detailed study using the reflected light microscope. However, a preliminary identification of these minerals could be realized as iron oxides composing of magnetite, goethite, ilmenite and leucoxene. They are encountered in all of the examined samples with different values. Their percentages vary from 18% to 47%.

3.1.2 Non-opaque minerals

The non-opaque minerals are mainly represented by amphiboles, epidotes, pyroxenes, zircon, garnet and staurolite.

a) Amphiboles are characterized by their green colour and distinct pleochroism. They are mainly represented by sub-angular green hornblende. Although most of the hornblende grains show strong pleochroism, yet few of them exhibit weak colour changes. Also, the majority of the mineral grains are altered especially along the mineral peripheries. Amphiboles are widely varied from 15% to 35%. They are more abundant in Qena and Kom Ombo formations than in the sediments of Ghawanim Formation. Amphiboles are mainly sourced from igneous and metamorphic rocks.

b) Pyroxenes as a group of important rock-forming silicate minerals found in many igneous and metamorphic rocks have the common formula is $XY(Si,Al)_2O_6$ (where X represents calcium, sodium, iron^{+2} or magnesium and more rarely zinc, manganese, or lithium and Y represents ions of content of pyroxenes relative to Qena and Kom Ombo formations. smaller size, such as chromium and aluminum). They are recorded in all the analyzed samples with different amounts varying from 4% to 41%. They are almost represented by hypersthene, enstatie and yellowish green or purple aguite. They are predominated in igneous and metamorphic rocks. They are widely spread in basltic types. The Ghawanim Formation attains higher content of pyroxenes relative to Qena and Kom Ombo formations.

c) Epidotes are represented in all examined samples by zoisite mineral. The minerals grains are distinguished by the pale lemon-green colour but some of which are colorless. Epidote occurs as subrounded grains, occasionally containing some minute inclusions of opaque minerals. Some minerals show faint pleochroism, whereas others are non-pleochroic. Most of the epidote grains show high interference colour. Its oercentage varies from 12% to 25%. Epidote is an abundant rock-forming mineral, but also it is considered of secondary origin. It occurs in schistose rocks of metamorphic origin. It is also a product of hydrothermal metamorphism of various minerals (feldspars, micas, pyroxenes, amphiboles) composing igneous rocks.

d) Zircon is an accessory mineral. It is present by various amounts in most of the examined samples. The mineral occurs in different shapes; prismatic with rounded or broken terminations, euhedral with pyramidal ends and irregular to rounded. The majority of the grains are transparent, although few are translucent and/ or cloudy or even opaque. The grains are mostly colorless but some of them show faint pink coloration. Zircon shows very strong relief and parallel extinction. The mineral is characterized by numerous inclusions of different types, colors, forms, and arrangement. However, zircon grains free from inclusiona are also present. Zircon is recordrd by amount varying from 1% to 10%. Zircon is an accessory mineral in igneous and metamorphic rocks.

e) Garnet is present in traceable amounts in these sediments varying from 1% to 4%. It is identified by isotropic and very high relief characters as well as colorless and rose grains. Most of the mineral grains are euhedral to subhedral. The majorities are transparent while as others appear with cloudy surface. Some grains show highly dendritic furrowed surface. Occasionally, some irregular broken grains with conchoidal fractures are recorded.

f) Rutile is characterized by its marked red to yellowish- and reddish-brown color and pleochroism. The mineral grains are determined by short prismatic bipyramidal and subhedral fragments. Rutile is represented by amounts varying from 1% to 3%.

g) Tourmaline occurs as long prismatic grains with colours varying from green to brown and from yellow to pink. It occurs in the form of elongate prismatic grains of subrounded to rounded corners. It is rarely presented, and its percentage is 1%.

h) Staurolite is distinguished by its golden yellow color and distinct pleochroism. The minerals grains show irregular shapes with rounded edges. Occasionally, euhedral and subhedral grains are observed. The mineral is presented by very rare amounts reaching 1%. It is considered as metamorphic mineral of intermediate to high grade.

According to the cluster tree diagram (Figs. 3), the studied Pleistocene aquifer sediments could be classified into two classes:

1- The older sediments (from depth 39m to 89m):

These sediments are composed of coarse quartzose sand and gravel lacking of basement fragments and theses sediments contain higher frequencies of amphiboles (up to 35%) which contain high iron and magnesium ions in their structure. Amphiboles are minerals of either igneous or metamorphic origin. In the former case, they are occurring as constituents (hornblende) of igneous rocks, such as granite, diorite, and andesite and have high percentage of opaques, garnet and epidotes (Fig. 4). Epidote contains high iron and magnesium ions. These sediments have low amounts of pyroxenes and zircon. Statistically these sediments could be differentiated according to the previously data into two sub-groups as Qena Formation (from 55 to 89 m in depth) and Kom Ombo Formation (from 39 to 54 m in depth).

Sediments of the Kom Ombo Formation have been accumulated by means of the rivers draining the Red Sea Range with the uncovered basement terrain in Egypt and northern Sudan. These sediments were termed proto-Nile sediments by [19] and considered to be of early Pleistocene age. These sediments are higher in opaques, garnet, rutile and amphibols and low in pyroxene, epidotes and zircon. According to source area characteristics, the sediments of the Qena and Kom ombo formations were wholly derived from provinces located within Egypt. It means that these sediments are of non-Ethiopean origin.

These sediments composed of medium to fine sandstones and have higher amounts of pyroxenes (up to 44%, Fig. 4) which contain iron and magnesium ions in their structure. Aegirine and augite is minerals of either igneous or metamorphic origin but they are predominantly widespread in volcanic types such as basalt. These sediments may attest their derivation from the Ethiopian high lands that are formed from volcanic rocks and nterpreted as the connection of the Egyptian Nile by the Blue and Atbara tributaries.

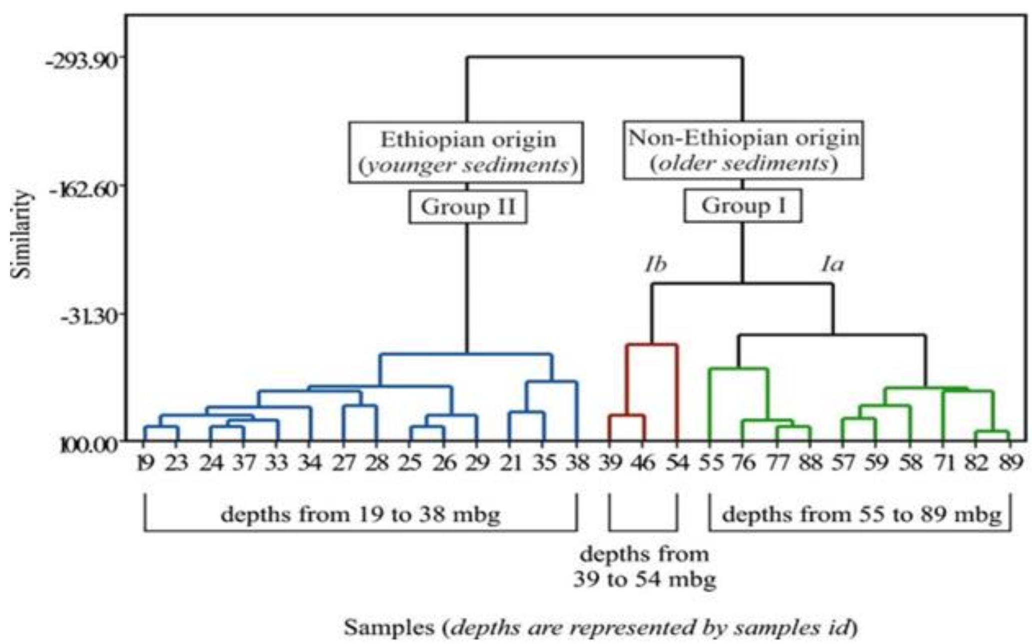

Fig. (3): The cluster tree diagram shows the sediments samples are differentiated into two big essential groups.

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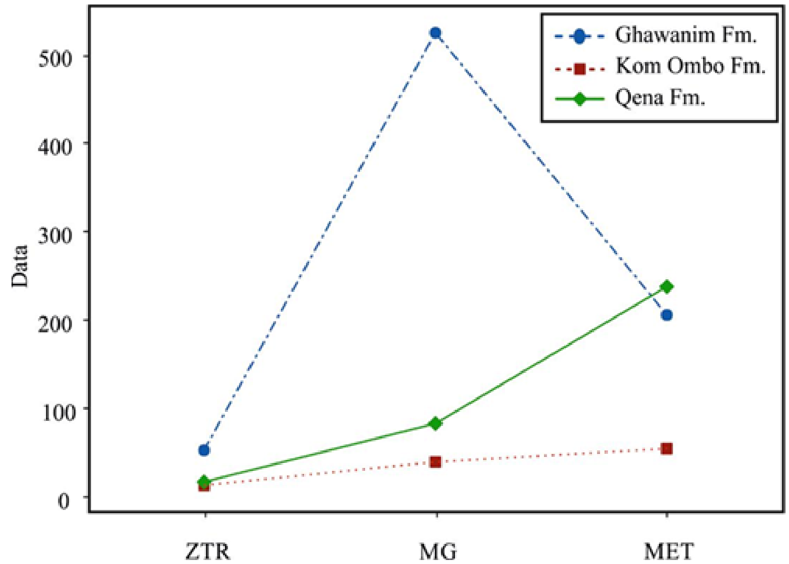

Fig. (4): The origin of the Qena, Kom Ombo and Ghawanim formations, ZTR: zircon-tourmaline-rutile, MG: magmatic and MeT: metamorphic origins.

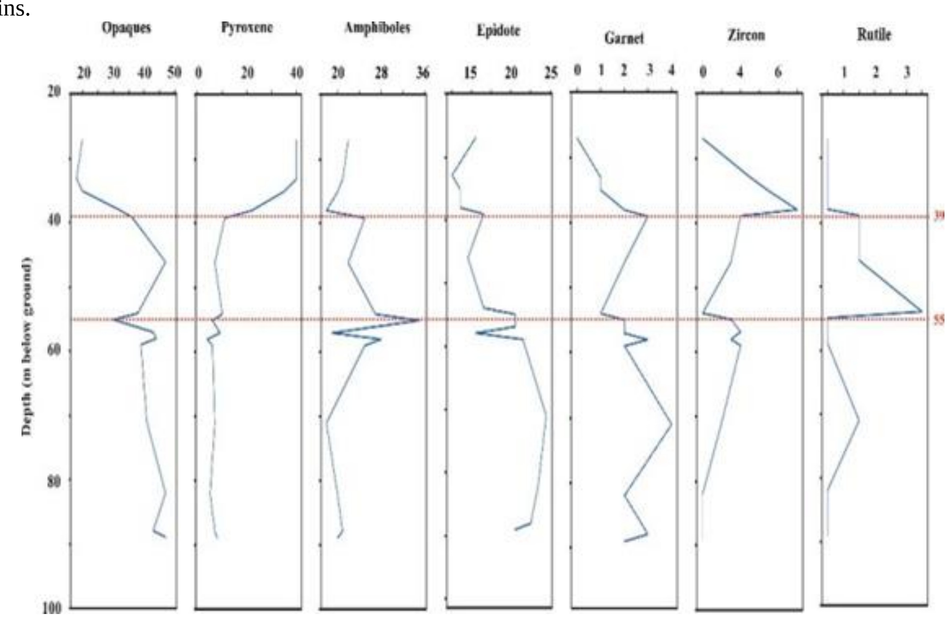

Fig. (5): the relation between the heavy minerals percentage within the depth (m below ground)

On the other hand, these sediments have relatively low percentages of opaque, epidotes, rutile and amphiboles which preclude the Egyptian source. Sediments of Ghawanim Formation were firstly introduced by [5] to describe Nile sandy sediments exhibiting the first appearance of the heavy mineral. The Figures (4&7) show that the Qena Formation was completely resulting from provinces placed within Egypt. It means that these sediments are of non-Ethiopean source, and sediments of the Kom Ombo Formation have been accumulated by means of the rivers draining the Red Sea Range with the uncovered basement terrain in Egypt.

2- The younger sediments (from depth 19m to 38m)

The sediments of Ghawanim Formation are of varied source (Egyptian and Ethiopian). Opaques vary from 38-47% in olde rsediments to 14-38% in younger ones. Amphiboles range from 18-34% in older sands to 15-25% in younger constituents. Pyroxenes vary from 3-10% in older types but reaching up to 44% in younger sediments. Epidotes are common in older sediments reaching up to 27% but diminishing to 10% in the younger ones. Zircon is more concentrated in the older sediments reaching 4% but decreasing to 0% in the younger sediments. Garnet is being more famous among the oldest sediments reaching 4% and its content reducing to 0% in the youngest sediments. Rutile, staurolite, and tourmaline are the least in abundant heavy minerals and are more encountered in the younger sediments. The Qena and Kom Ombo formations (early Pleistocene) are characterized by high percentage of opaques, amphiboles, garnet, epidotes and zircon. The compositional characteristics of these sediments indicate their derivation sandy sediments which widely distributed in the Eastern Desert. It means that these sediments are of non-Ethiopean origin. Sediments of Ghawanim Formation (late Pleistocene) are of mixed origin (Egyptian and Ethiopian) and are ascribed to the first appearance of Ethiopian heavy mineral assemblages (pyroxenes > amphiboles>garnet).

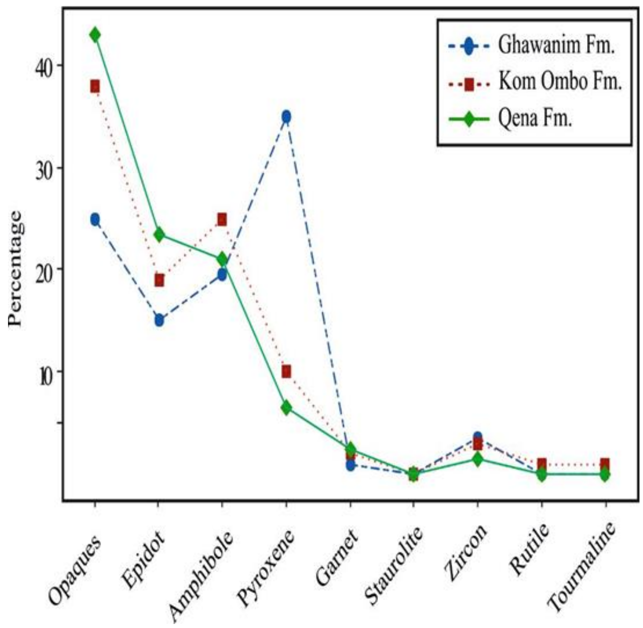

Fig. (6): The distribution of the non opaque minerals within the different formations.

3.1.3 Heavy mineral indices

3.1.3.1 ZTR index

Significant concentration has been centered on the concept of the maturity of sandstones [20] and [21]. The ZTR index got show immature to mature sediments [22]. A maturity index is the zircon-tourmaline-rutil\e (ZTR) index is the percentage of the combined zircon, tourmaline and rutile grains among the transparent, non micaceous, detrital heavy minerals. Because of their high mechanical and chemical stability, zircon, tourmaline and rutile are concentrated in sandstones become progressively more quartzose. In other words, the assement of the degree of sediment recycling can be expressed by the concept of the zircon, tourmaline and rutile (ZTR) index since these minerals trend to become concentrated during recycling [23] The zircon -tourmaline- rutile (ZTR) index was calculated for the analyzed samples and the average for the different lithostratigraphic units was also considered. The highest average ZTR value (6%) was found in the Kom Ombo Formation and considerably decreases up ward within the El Ghawanim Formation (4%).

3.1.3.2 Pyroxene, amphibole and epidote indices

The pyroxene indexes (Ipyx), amphibole index (IAmph) and epidote index (IEpd) were calculated for the examined samples according to the equations of [7]. These indices were calculated for the transparent, non-micaceous, heavy minerals as following:

(Ipyx) = (pyroxene% ⁄ (pyroxene% + epidote %))*100
(IAmph)= (amphibole% ⁄ (amphibole%+ pyroxene %))*100
(IEpd) = (epidote % ⁄ (epidote % + amphibole %))*100

The pyroxene index (Ipyx) shows the maximum value (80%) in the sediments of the Ghawanim Formation whereas the minimum value (11%) was found in the sediments of the Qena Formation. The amphibole index (IAmph) recorded the highest value (88%) in the Qena Formation, but the minimum value (26%) was found in Ghawanim Formation sediments.

The Epidote index (IEpd) recorded the highest value (60%) in the Qena Formation sediments whereas it achieves the lowest value (29%) in the sediments of the Ghawanim Formation.

The highest value of the (MG) was documented in the younger sediments (Ghawanim Formation) while the lowest value was found in the older sediments (Qena Formation). The highest value of the (MET) was recorded in the older sediments (Qena Formation) but the lowest value was estimated in the younger sediments (Ghawanim Formation). Conclusively, the diagrams of the heavy minerals indices are able to differentiate the Ethiopian and non-Ethiopian sediments. Alevel headed difference for the Qena, Kom Ombo and Ghawanim formations Fig. (4 &7).

3.2 Geochemical characterization

The geochemical characterization of the Quaternary sediments is very important to differentiate between the lithostratigraphic units which already discriminated to Qena Kom Ombo and Ghawanim formations by their mineralogical characteristics.

3.2.1 Iron (Fe)

whereas the minimum value (11%) was found in the sediments of the Qena Formation. The amphibole index (IAmph) recorded the highest value (88%) in the Qena Formation, but the minimum value (26%) was found in Ghawanim Formation sediments. The Epidote index (IEpd) recorded the highest value (60%) in the Qena Formation.

Sediments from the Qena Formation display a relativity wide range of iron values varying from 664 to 37416 mg/kg) with a mean value of 15155 mg/kg. The estimated iron content in the examined sediment samples from Kom Ombo Fm. ranges from 4469 to 23345 mg/kg with a mean value of 10827 mg/kg. With respect to Ghawanim Fm. ranges 12374 to 20467 mg/kg with a mean value 17217 mg/kg. It is obvious that iron is getting high in the Quaternary sediments in the Ghawanim, Kom Ombo and Qena formations related to the high ferromagnesian minerals which contributed to ferromagnesian minerals of the Ethiopian origin [5].

3.2.2 Manganese (Mn)

With respect to the Qena Formation, the measured manganese of the analyzed sediment samples shows a range varying from 0.4 to 885 mg/kg with an average of 250

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mg/kg. Although manganese of Qena Formation is relatively lower than that of the Kom Ombo Formation range from 42 mg/kg to 1360 with a mean value 368 mg/kg. Regarding the manganese content of Ghawainm Formationvalue (29%) in the sediments of the Ghawanim Formation. mean = 868 mg/kg) is markedly higher than that of the Kom Ombo, Qena formations (mean= 368, 256 mg/kg respectively). It ranges from 139 to 2308 mg/ kg. The high manganese values of Mn in Ghawanim Formation in the bulk sediments are controlled by the content of ferromagnesian minerals in the Ethiopian basaltic plateau.

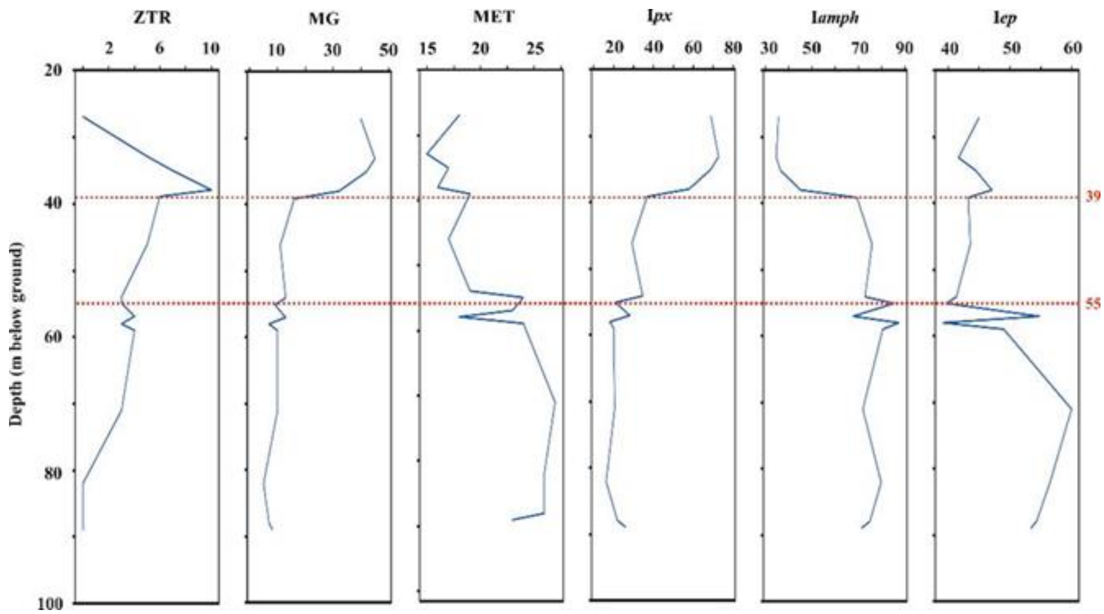

Fig. (7): the relation between the sediment's origin within the depth (m below ground)

3.2.3 Zinc (Zn)

The measured zinc content in Qena Formation is generally high and shows a wide range varying from 10 to 3830mg/Kg with an average of 917 mg/Kg. Regarding Kom Ombo Formation, zinc level (mean = 1267 mg/kg) is markedly higher than Qena Formation (mean= 917 mg/kg). With respect to Ghawanim Fm., zinc of sediments is generally lower and more uniform than that of Kom Ombo and Qena formations. Here, zinc fluctuates from 96.4 to 270 mg/kg with a mean value of 172 mg/kg. Zinc concentrations in bulk sediments are generally lower and more uniform in El Ghawanim Formation than that of Kom Ombo and Qena Formations (Fig. 8). The distribution of Zn in sediments is primarily controlled by the abundance of ferromagnesian silicates and detrital oxides, (such as magnetit [24].

3.2.4 Titanium (Ti)

Titanium content in Qena Formation is in general high and shows a narrow range varying from 0.00to 1676 mg/kg with an average of 558 mg/kg. Regarding titanium content in Kom Ombo Formation is relativity low and shows a narrow range varying from 0.00 to 1019 mg/kg with an average of 329 mg/Kg. With respect to Ghawanim Fm., titanium of sediments is lower than that of Kom Ombo Fm. and Qena formations. Here, titanium changes from 0.0 to 9.52 mg/kg with a mean value of 3.13 mg/kg.

3.2.5 Chromium (Cr)

Relating to the Qena Formation the cr of the analyzed sediments samples show very high values varying from 43.4 to 226 mg/kg with an average of 111 mg/kg. As regards to the Kom Ombo Formation the measured chromium of the analyzed sediments samples varying from 24.6 to 320 mg/kg with mean of 107 mg/kg. Concerning the sediments of Ghawanim Formation, the average chromium content varying from 41.6 to 68 mg/kg with mean of 56.4 mg/kg. Chromium values of Ghawanim Fm. in the bulk sediments are lower than Kom Ombo and Qena formations reflecting their natural association in magnetite and ilmenite [24].

3.2.6 Lead (Pb)

Sediments of the Qena Formation display Pb values varying from 0.2 to 42.2 mg/kg with a mean value of 10.9 mg/kg. The expected lead content in the examined sediments samples from Kom Ombo Formation ranging from 0.6 to 19.6 mg/kg with an average value of 8.7 mg/kg. Regarding Ghawanim Formation Pb content of the examined sediments samples, ranging from 3.2 to 9 mg/kg with a mean value 6.68 mg/kg. It is clear that lead is getting higher in Qena Fm. than Ghawanim through the Kom Ombo formations due to its mobility in late-stage magmatic processes [25].

3.2.7 Cadmium (Cd)

Sediments of Qena Formation show cadmium values ranging from 0.8 to 11.8 mg/kg with a mean value of 2.65 mg/kg. The expected cadmium content in the examined sediments samples from Kom Ombo Formation varying from 1.2 to 4.2 mg/kg with an average value of 2.8 mg/kg. Regarding Ghawanim Formation cadmium content, of the examined sediments samples, ranging from 1.8 to 2.4 mg/kg with a mean value of 2.04 mg/kg. It is clear those sediments from the Ghawanim Formation are relativity low in cadmium. Cadmium values of Kom Ombo and Ghawanim formations in the bulk sediments are lower than Qena Formation because it is found in trace amounts in some silicate minerals. Generally lower levels of cadmium occur in igneous and metamorphic rocks.

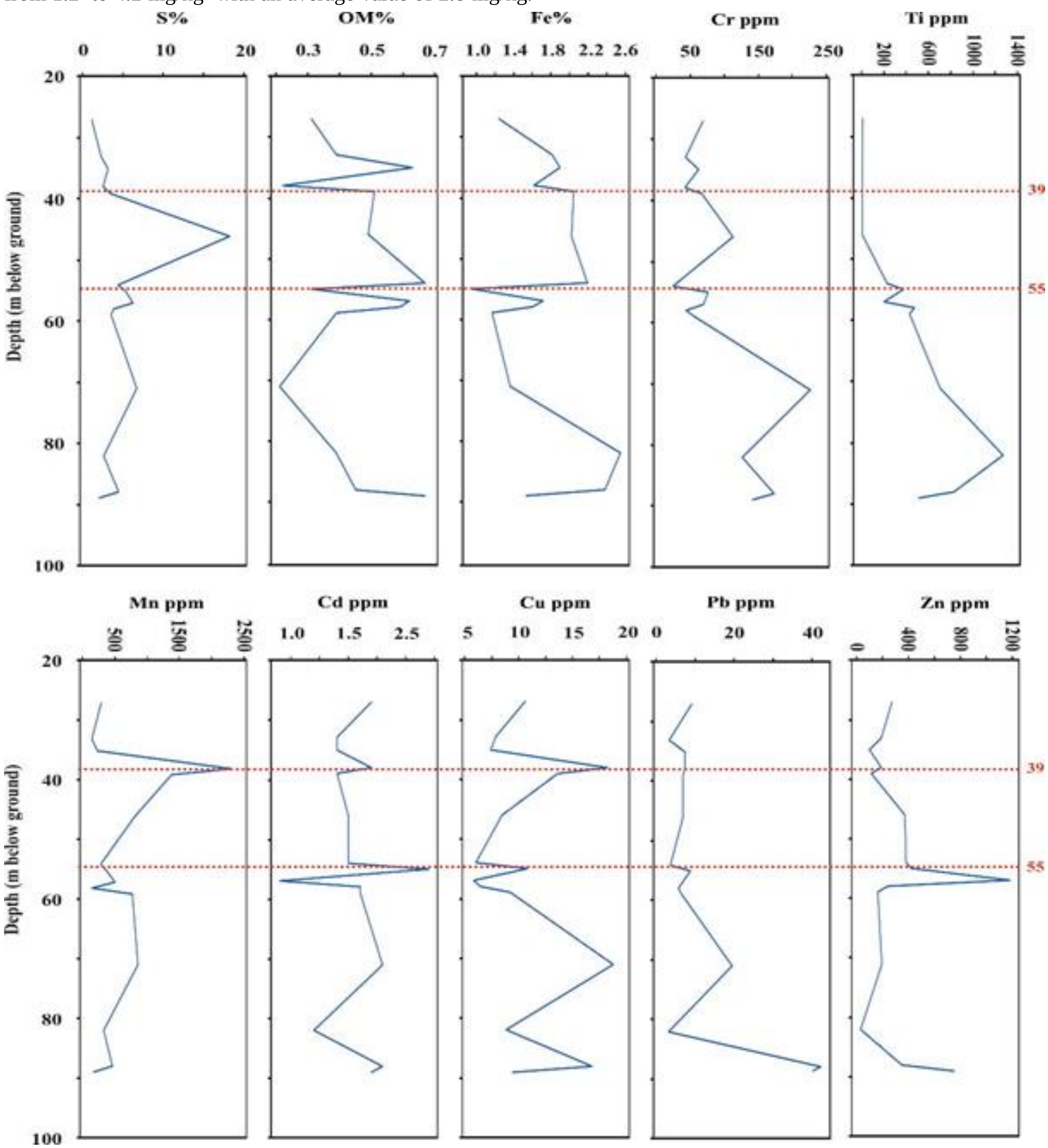

Fig. (8): the relation between the chemical elements within the depth (m below ground).

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3.2.8 Copper (Cu)

The analyzed copper content in the analyzed sediments samples from Qena Formation ranging from 3 to 28 mg/kg with an average value of 10.7 mg/kg. Sediments of the Kom Ombo Fm. displays copper values ranging from 4 to 26.8 mg/kg with a mean value of 9.8 mg/kg. Regarding Ghawanim Formation, copper content of the examined sediments samples have very wide range of copper concentrations varying from 7.4 to 18.2 mg/kg with average value of 11.52 mg/kg. It is clear that copper is getting higher up ward in Quaternary sediments of the Qena Formation (Fig. 8) (mean=10.7 mg/kg) through the Kom Ombo Formation (mean = 9.8 mg/kg) and Ghawanim Formation (mean= 11.52 mg/kg) because copper may be reorganized during low-grade metamorphism.

3.2.9 Organic matter (OM)

The organic matter content in the analyzed sediments samples from Qena Formation ranging from 0.21% to 0.99% with an average value of 0.61 %. Sediments from the Kom Ombo Fm. show organic matter values ranging from 0.11% to 0.78% with a mean value of 0.5%. Regarding Ghawanim Formation, the organic matter content, of the examined sediments samples varying from 0.22% to 0.63% with average value of 0.41%. It is clear that organic matter is getting higher downward in Quaternary sediments from the Qena Formation (mean=0.61%) through the Kom Ombo Formation (mean= 0.5%) and Ghawanim Fm. (mean= 0.41%). It is obvious that organic matter is getting higher downward in Quaternary sediments from Ghawanim Fm. through the Kom Ombo and Qena Formations (Fig.8) due to an anoxic condition and reducing setting are responsible for the presence of organic matter with depth.

3.2.10 Sulferitic pyrite (S%)

With respect to the Qena Formation, the measured sulferitic pyrite of the analyzed sediments samples shows a narrow range varying from 2% to 9.5% with an average of 5.2%. Regarding to the Kom Ombo Formation, the measured sulferitic pyrite of the analyzed sediments samples shows a very wide range varying from 4.36 % to 29.3% with mean of 13.7%. Concerning the sediments from Kom Ombo Formation the average sulferitic pyrite content (mean = 13.59%) is markedly higher than that of the Ghawanim, Qena formations (mean= 2.52%, 5.2% respectively). Despite generally higher contents in the sediments samples from the Ghawanim Formation, sulferitic pyrite displays marked irregular vertically variation through out the area. The presence of pyrite in sediments is the source of sulfer (Fig. 8).

4 Summery and Conclusion

Twenty-seven representative samples from the Quaternary Nile sediments in the Sohag region were collected to identify heavy minerals association. The samples contain a significant amount of opaque and non-opaque heavy minerals. The non-opaque minerals include epidotes, pyroxenes, amphiboles, zircon, garnet, staurolite, tourmaline and rutile. The most abundant heavy minerals are and amphiboles, pyroxenes and epidotes. The heavy minerals differ among the different formations and reflecting their

provenance regions. The heavy mineral collections are important in estimating the changes of the source rocks from which the sediments were derived. The calculated heavy mineral indices (e.g ZTR, (Ipyx), (IAmph), (IEpd), MG and MET) showed a significant difference v 7 for sediments sources. The different diagrams of the heavy mineral indices and heavy minerals relationships have been able to differentiate between the Ethiopian (younger) and non-Ethiopian (older) sediments and the depth of each other. Statistically these sediments related to two sub-groups, classified as the older Qena Formation (from 55 to 89m in depth), Kom Ombo Formation (from 39 to 54m in depth) and the younger Ghawanim sediments (from 19m to 38m) in depth.

The bulk sediment samples of Ghawanim Formation have higher values of iron and manganese than those of Qena and Kom Ombo formations. The high iron values of Ghawanim Formation sediments are related to the high content of silicate minerals in the Ethiopian basaltic plateau from which this formation detritals were sourced Zinc content of the sediments in bulk samples is generally lower and more uniform in Ghawanim Formation than that of Kom Ombo and Qena formations.

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