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ORIGIN AND ECONOMIC ASPECTS OF SOME KAOLIN DEPOSITS AT WADI EL-ESSEILA, WEST CENTRAL SINAI, EGYPT.

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ABSTRACT

The present communication deals with some kaolin horizons at Wadi El-Esseila, West Central Sinai, in an attempt to deduce their origin and evaluate their economic potentialities. 147 representative kaolin samples were chemically analysed for their major element oxides while 19 were selected, in addition to 11 samples from the host Nubia Formation and subjected to trace-element analysis. The mineralogy of the deposit has been identified through D.T.A. and X-ray diffraction analyses. The heavy minerals were separated and their types as well as characteristics were interpreted.

Based on these studies, the kaolin deposits are assigned a detrital sedimentary fluvio-marine environment & were derived principally from the southern basement rocks. However, more than one province have contributed to their formation. Not all the kaolin horizons are economically of the same grade.

INTRODUCTION

Wadi El-Esseila area lies at West Central Sinai, near the eastern side of Gulf of Suez; about 25 Km to the north-east of Abou-Zneima (Fig. 1). The Wadi trends NNE-SSW sepa-

rating Gebel El-Esseila to the east and Gebel Abu-Ediemat to the west.

The kaolin deposits are represented by four and in some places five horizons locally termed Horizons I-IV, where Horizon (I) is given to the lowermost exposed level in the Wadi. Each horizon is typified by flat & disconnected lenses that range in thickness from 0.5 to 4 meters. Worthmentioning that Horizon II as well as Horizon III represent the thickest ones and are laterally extended for longer distances. For this, stress has been given to these two horizons being subject of economic scale.

The five kaolin horizons are intraformationally layered with the Nubia Formation which is given a questionable lower Cretaceous age? on basis of its relative stratigraphic position. Figure 2 shows a composite columnar section for the study area. The kaolin horizons are separated from each other by interval of about 2-8 mts, each displaying gradation into the sandstone through a thin kaolinitic sandstone.

Chemistry of the kaolin horizons:

1- Major oxides:

147 samples (114 composite & 33 spot) representing kaolin horizons II & III were chemically analysed for

their major oxides SiO_2, Al_2O_3 + TiO_2, Fe_2O_3, CaO, MgO and L.O.I. Both horizons display wall to wall variation either in grade or in colour. Each horizon was compositely sampled but separately analysed. The thickness at sampling locations was measured and average oxides content for the whole lens is calculated.

1.1. silica:

The silica content showed wide variation (tables 1-4), spot sample analysis revealed that silica content increases toward contact with sandstone. As silica is an inverse function of kaolin grade, the central parts of the lens render higher grade.

1.2. Alumina + Titania:

The close association between Al_2O_3 and TiO_2 with kaolin grade has been proved by many workers: [1,2,3] among others. It is a fact that alumina content is directly proportional to the kaolin grade and inversely to the silica content (Fig. 3).

Variation in the two oxides (Al_2O_3 & TiO_2) together as well as variation of each separately in 18 representative (11 composite + 7 spot) samples is given in tables 1-4.

Normal values of kaolin grade are obtained, yet high

titania could be observed in some samples. This relatively high titania in such deposits may be attributed to:

a- The presence of some Ti-bearing heavy minerals as rutile, ilmenite, and leucoxene, Such factor is verified by heavy-mineral studies as will be shown later.
b- Minor amounts of Ti may replace Al in the octahedral position or Si in the tetrahedral position.
c- Some amorphous or hydrated TiO_2 may be deposited together with tiny kaolinite flakes [4]

1.3. Iron oxide:

Colour shades of kaolin usually reflect iron content among other elements. Yellowish brown to reddish brown or even purple colour is usually noticed near sandstone wall rocks. It is thought that a large part of this iron oxide is due to precipitation from colloids that came from the highly porous & permeable sandstone to the kaolin causing its staining. The content of iron oxides in different coloured kaolin samples is listed in tables 1-4.

1.4. Calcium oxide:

Calcium oxide is present in minor amounts. Tables 1-4 show its range in the different samples. Worthmentioning that CaO is considered to be one of the harmful oxides in kaolin refractory.

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1.5. Magnesium oxide:

MgO as well follows CaO in its presence as very subordinate. It never exceeds 0.44% in average.

Chemical data presentation:

For economic purpose, chemical data is presented by preparing isochemical maps for the different analysed element-oxides in each lens. Also average values in both lenses have been calculated. In addition, isopach maps were constructed. Selection of Gebel Abu Ediemat only for such presentation was essentially due to the larger number of representative samples it yielded.

From isopach & isochemical maps, the following observations could be given:

a- The thickness of both horizone (II & III) was found to be increasing via NW direction (Fig. 4).

b- The average SiO_2 content showed increase towards SE. This is true for both horizons as a whole, yet the remarkable variation in SiO_2 content revealed in horizon II rendered stating of a general trend is rather risky (fig. 5).

c- Average (Al_2O_3 + TiO_2) showed observable increase via NW direction (Fig. 6), being directly proportional with thickness but inversely with average SiO_2.

d- Iron oxide, although varies in the one horizon, yet a general slight increase could be deduced towards NE and SE directions (Fig. 7).

2- trace-element analysis:

Trace-element studies on clay deposits in general are believed to have something to do with the depositional environment but nothing regarding economicity. Boron, Vanadium, Cobalt, Nickel and Copper are among the useful trace elements in that connection. Nineteen kaolin and 11 sandstone samples (from the host Nubia Formation) were optically arced by means of Q-24 medium quartz emission sepectrograph and analytical results for the mentioned trace elements are listed in tables 5 & 6.

Boron as a paleosalinity indicator and hence differentiating between marine and lacustrine environments has been stressed upon by Goldschmidt and Peter [5]. This has been confirmed by Harder [6] and Levinson & Ludwick [7] when they found that sediments near river mouths are characterized by lower boron content than those deposited in open sea conditions, Also, Degens et al. [8] concluded that boron as well as rubidium are higher in marine shales opposite to gallium. Keith & Degens [9] reconfirmed the previous conclusions adding the elements Li, S, Mn, Ni, F, and Sr to be higher in marine shales while Ga, Cr, and V are higher in fresh water shales. Harder [10] concluded that boron content in

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clays is dependant on: depositional conditions, grain size and type of dominating clay mineral. In addition, Parks and White [11] reported the inability of the H-saturated form of kaolinite and bentonite for boron fixation. In other context, Porrenga [12] attributed increase of boron absorption by clays to temperature increase.

It is worthy to note that boron content in Wadi El-Esseila clays is considered among the low values attained by clays. This leads to conclude that such clay deposits are of freshwater media, not high in tempereture and were formed in H-saturated form.

On the other hand, Porrenga [12] emphasized that Ni, Cr and Sr are slightly higher in marine clays than fresh water clays. Wadi El-Esseila clays show relatively high Mn & Sr whereas Ni & Cr Values are matching those of marine clays.

Such discrepancies in trace element contents of Wadi El-Esseila clays as regards to certain environmental conditions make hypothesis of a fluviomarine environment is possible. More support is evidenced on applying V-Co+Ni-Cu diagram constructed by Angino and Andrews [13] for differentiating sedimentation conditions.

The plots of Wadi El-Esseila clays lie mostly in or very near from shallow-water sediments field.(Fig. 3)

Mineralogy of kaolin horizons:

Twenty five samples were derivatographically analysed where as 21 samples were investigated using X-ray diffraction analysis to identify the mineralogy of the chemically analysed kaolin horizons.

Differential thermal analysis results showed that kaolinite is the main constituent (Figs. 9 & 10). In addition, kaolinite mineral displays wide range in crystallinity from weak to rather well crystalline. The well crystallinity nature is rather dominant among samples representing Horizon II. The high percentage of kaolinite affects the α-β inversion peak of quartz rendering it masked even in those samples chemically proved to be of high quartz-content.

Worthmentioning that X-ray diffraction interpretation matched well the results of derivatographic analysis. The degree of peaks sharpness indicates the well crystalline nature of kaolinite displayed by Horizon II samples only (Fig. 11). Moreover, results hitherto given from chemical analysis concerning the inverse relation between quartz content and kaolinite grade is reconfirmed.

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Heavy minerals:

Heavy minerals study is affectionally used in interpreting type of source rocks, environmental conditions and to some extent diagenesis. Twenty sandstone samples as well as 12 kaolins were subjected to heavy mineral separation techniques and microscopically examined. Results are summarized in the following:

1- Opaques form high percent relative to others in heavy fraction.
2- Zircon, tourmaline, rutile, staurolite and biotite represent the non-opaque heavy minerals, displaying different forms, sizes and colours.
3- Zircon, tourmaline and rutile -usually considered as ultrastable- dominate the other non opaques.
4- The index figure for sandstone samples is little bit higher than that of kaolin ones but grading to be matched near contacts.

From these results one reaches the following conclusions:

1- The essential heavy mineral assemblages recorded from the Nubia Sandstone samples and their intercalated kaolin are more or less comparable to those recorded by several authors in the Nubia Sandstone at different localities [2,3, 14-18].
2- The variation in form, size and colour of the ultrastable

nonopaques may lead to the assumption that more than one provenance acted as a source.

3- The high frequency of the ultrastable non-opaque minerals has been explained in two ways; one considers that mineralogy of the Egyptian sediments appears to be governed by both depositional environment and provenance [16]. The other relates it to post-depositional changes with special emphasis on the effect of intrastratal solutions [17]. However, Hubert [19] gave little attention to the effect of intrastratal solutions in determining the heavy minerals assemblage stating that it is a local phenomenon. Meanwhile, two points must be mentioned to unravel which factors were controlling in obtaining such high percentage of the ultrastable non-opaque minerals. These are the following:
   a- Matching or nearly so of the index figure of both hard, permeable Nubia sanstone and that of soft, impermeable kaolin is in favour of the first explanation.
   b- The presence of etched together with unetched mineral grains in the same sample opposes the effect of intrastratal solutions as an explanation,

4- Hubert [19] used ZTR index (% of combined ziron, tourmaline and rutile) to define sandstone types. He mentioned that such index is high (> 90%) in tectonic sandstone He added that in such sandstone types, a lot of zircon, tourmaline and rutile grains, different in colour,

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inclusions and form, are usually characteristic. Worthy to mention that ZTR index in Wadi El-Esseila Nubia sandstones exceeds 90%.

ORIGIN OF WADI EL-ESSEILA KAOLIN DEPOSITS

Data and observation provided by mineralogical studies lead speculation for history of formation of Wadi El-Esseila kaolin as follows:

-Weathering of the basement rocks (most probably of acidic composition as indicated by the low Fe content) which occur to the southeast of the study area. The weathering products were mainly formed of feldspars and quartz grains.
-Feldspars were changed into kaolinite, by chemical weathering under acidic conditions with high rainfall and good drainage.
-These products were transported by numerous northwards streams and were deposited in geomorphologically shaped depressed areas, followed by Nubia Sandstone deposition.
- It seams plausible that this scenario has been repeated more than once to form the different horizons in the area.

The presence of the sedimentary features that characterize sediments formed by deltaic processes (such as the lateral and vertical variations in the amount of kaolinite, sand and iron staining within short distances), the presence

of the deposit in the form of irregular isolated lenses and the absence of minerals of hydrothermal origin such as dickite and nacrite in addition to the absence of criteria supporting other modes of formation indicate sedimentary environments for Wadi El-Esseila kaolin deposits.

ECONOMIC ASPECTS OF WADI EL-ESSEILA KAOLINITES

From the chemical point of view, the kaolin of the study area is satisfactory for the manufacture of refractories, this is mainly due to its relatively high alumina content which is accompanied by minor amounts of both iron, calcium and magnesium oxides.

SUMMARY AND CONCLUSION

Kaolin deposits of Wadi El-Esseila are found in the form of separated disconnected lenses within an unfossiliferous Nubia Sandstone deposit which is given a questionable lower Cretaceous age. 147 kaolin samples were chemically analysed in order to evaluate the potentialities of the kaolin deposits for manufacture. The thicknesses of the most economic kaolin lenses (the second and the third ones) were traced laterally and the average contents of the oxides SiO_2, $(Al_2O_3 + TiO_2)$ and Fe_2O_3 were calculated. Isochemical maps were drawn and correlated with their thickness maps.

The trace element data of 19 kaolin samples and 11

sandstone ones showed that both of the kaolin and sandstone were deposited under a shallow water environment most probably a fluvio-marine one. In addition, 25 kaolin samples were derivatographically analysed and 21 samples were investigated by X-ray diffraction analysis. Results indicate that kaolinite is the main constituent, associated with some quartz and no other clay minerals are recorded.

Zircon, tourmaline, rutile, staurolite and biotite represent the non opaque heavy minerals in both the sandstone and interformational kaolin horizons. The ultrastable non opaque heavy minerals (zircon, tourmaline and rutile) are -by far- the most frequent among the other non opaques. They display differences in form, size and colour which may lead to assume that more than one provenance was contributing for the same mineral species. The basement rocks lying to the southeast of the investigated area seems to be playing the principal role, probably in addition to a reworked sedimentary provenance.

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Table (1): Chemical analysis results for the composite samples collected from the second and the third kaolin lenses; G. El-Esseila

Sample number	level	Thickness (cm)	SiO_2%	Average SiO_2	$(Al_2O_3+TiO_2)$%	Average $Al_2O_3+TiO_2$	Fe_2O_3%	Average Fe_2O_3	L.O.I.%	CaO%	MgO%	TiO_2%
100/a	II	55	48.34	48.37	37.07	37.02	1.79	1.67	12.63	0.01	t.	n.d.
100/b		20	48.44		36.90		1.34		12.76	0.02	t.	n.d.
101/a	II	112	47.92	54.92	38.49	32.80	1.34	1.40	11.82	0.01	t.	1.00
101/b		26	53.56		33.74		1.79		10.82	0.02	t.	0.88
101/c		68	68.48		23.06		1.34		6.66	0.01	t.	1.08
102/a	II	34	51.00	49.56	36.02	36.30	1.79	1.59	10.70	0.02	t.	n.d.
102/b		90	49.86		36.20		1.34		12.20	0.01	t.	n.d.
102/c		40	49.19		36.77		1.97		11.86	0.01	t.	n.d.
103/a	II	65	48.18	47.97	37.60	38.04	1.35	1.35	12.77	t.	t.	n.d.
103/b		90	47.82		38.35		1.35		12.32	t.	t.	n.d.
104/a	II	50	47.70	48.08	37.81	35.68	1.79	3.88	12.24	t.	t.	n.d.
104/b		25	48.83		31.43		8.07		11.41	t.	t.	n.d.
105/a	II	54	47.98	47.98	37.71	37.71	1.79	1.79	11.96	t.	t.	n.d.
106/a	II	67	48.58	49.93	36.36	35.24	1.34	1.73	13.03	t.	t.	n.d.
106/b		30	52.95		32.75		2.60		11.29	t.	t.	n.d.
107/a	II	105	54.66	54.01	31.81	31.77	2.24	2.40	11.09	t.	t.	n.d.
107/b		55	48.49		35.78		2.24		13.12	t.	t.	n.d.
107/c		90	56.62		29.26		2.69		11.00	t.	t.	n.d.
108/a	II	70	54.44	58.68	31.41	27.44	3.14	3.99	11.21	t.	t.	n.d.
108/b		70	62.91		23.46		4.84		8.68	t.	t.	n.d.
109/a	II	70	54.51	52.68	29.86	32.19	3.59	3.14	11.62	t.	t.	n.d.
109/b		70	50.84		34.51		2.69		11.75	t.	t.	n.d.
110/a	III	84	51.10	54.19	36.32	33.57	1.79	1.79	10.77	t.	t.	n.d.
110/b		80	57.43		30.69		1.79		9.66	t.	t.	n.d.
111/a	III	83	53.04	55.60	33.56	31.88	1.79	1.79	11.27	t.	t.	0.97
111/b		83	58.16		30.21		1.79		9.55	t.	t.	0.90
112/a	III	74	55.19	56.63	32.90	31.62	1.35	1.12	10.51	t.	t.	n.d.
112/b		74	58.07		30.35		0.90		10.16	t.	t.	n.d.
113/a	III	103	52.33	53.58	32.66	31.44	3.50	3.99	11.06	t.	t.	n.d.
113/b		103	54.82		30.22		4.48		10.13	t.	t.	n.d.
114/a	III	50	53.32	52.60	34.53	33.97	1.97	2.33	10.83	t.	t.	n.d.
114/b		36	49.50		36.47		1.48		12.15	t.	t.	n.d.
114/c		60	54.70		32.00		3.14		10.12	t.	t.	n.d.
115/a	III	79	54.03	54.44	32.37	31.60	3.14	3.23	10.14	t.	t.	n.d.
115/b		109	55.27		29.02		4.04		10.76	t.	t.	n.d.
116	III	150	54.05	54.05	32.48	32.48	2.69	2.69	10.76	t.	t.	n.d.
117/a	III	150	69.18	62.49	19.87	25.42	4.01	2.89	6.92	t.	t.	n.d.
117/b		130	56.80		30.21		1.79		11.14	t.	t.	n.d.
117/c		120	60.29		27.16		2.69		9.49	t.	t.	n.d.

n.d. = not determined

t. = traces

Table (2): Chemical analysis results for the composite samples collected from the second and the third kaolin lenses; G. Abu Ediemat

Sample number	level	Thickness (cm)	SiO_2%	Average SiO_2	(Al_2O_3+ TiO_2)%	Average Al_2O_3+TiO_2	Fe_2O_3%	Average Fe_2O_3	L.O.I.%	CaO%	MgO%	TiO
118/a		43	47.36		36.87		2.69		13.10	t.	t.	1.
118/b	II	60	44.54	47.23	38.76	37.41	2.69	2.46	13.53	t.	t.	1.
118/c		35	49.83		35.76		1.79		12.18	t.	t.	0.
119/a		22	59.60		29.76		1.34		9.28	t.	t.	n.
119/b	II	78	47.26	49.48	38.37	36.52	1.79	1.72	12.57	t.	t.	n.
119/c		50	48.41		36.69		1.79		12.49	t.	t.	n.
120/a		7	55.22		30.41		2.41		10.85	0.60	0.24	n.
120/b		26	49.28		35.69		1.71		11.77	0.80	0.34	n.
120/c		40	47.95		35.87		1.38		13.04	0.95	0.44	n.
120/d	II	10	47.71	51.21	36.44	34.29	1.26	1.53	13.25	0.60	0.34	n.
120/e		10	50.69		34.36		2.14		11.45	0.80	0.29	n.
120/f		40	51.65		33.84		1.69		11.77	0.50	0.21	n.
120/g		60	54.12		33.02		1.28		10.95	0.20	0.15	n.
121/a		20	53.03		33.74		1.61		10.74	0.55	0.16	n.
121/b		25	49.85		35.74		1.70		12.23	0.10	0.06	n.
121/c	II	20	49.80	50.78	35.08	34.46	1.97	1.83	11.92	0.60	0.28	n.
121/d		90	48.47		36.30		1.72		12.46	0.55	0.19	n.
121/e		50	54.88		30.57		2.13		10.75	0.95	0.36	n.
122/a		20	47.48		36.97		1.30		12.79	0.86	0.30	n.
122/b	II	130	64.52	60.71	25.84	28.20	1.66	1.79	7.47	0.10	0.06	n.
122/c		30	52.84		32.89		2.56		10.60	0.55	0.20	n.
122/d		5	61.64		26.34		2.58		8.40	0.40	0.15	n.
123	II	100	60.05	60.05	27.92	27.92	2.25	2.25	9.03	0.20	0.06	n.
124/a		35	46.13		38.03		1.75		12.95	0.50	0.22	n.
124/b	II	75	45.88	48.12	38.14	36.54	1.76	1.63	13.17	0.40	0.25	n.
124/c		40	54.05		32.22		1.28		11.65	0.25	0.12	n.
125/a		35	46.91		37.82		1.38		12.90	0.35	0.16	n.
125/b	II	80	46.71	49.00	37.22	35.70	2.16	1.98	12.50	0.70	0.27	n.
125/c		35	56.31		30.12		2.15		9.82	0.95	0.34	n.
126/a		23	47.28		37.04		1.71		12.51	0.70	0.31	n
126/b	II	117	47.89	49.56	37.12	35.85	1.28	1.36	12.40	0.60	0.28	n
126/c		30	57.80		29.97		1.39		9.57	0.65	0.22	n
127/a		10	47.95		37.45		1.31		12.06	0.61	0.21	n
127/b	II	100	45.63	46.75	37.66	37.12	2.13	1.99	13.65	0.45	0.16	n
127/c		25	50.72		34.89		1.71		11.89	0.25	0.09	n
128/a		50	47.76		37.55		1.28		12.57	0.35	0.15	n
128/b	II	85	46.14	46.80	37.61	37.51	1.73	1.62	13.30	0.55	0.22	n
128/c		20	47.24		37.02		2.04		12.46	0.70	0.20	n

(2) Cont.

e ar	Level	Thickness (cm)	SiO_2%	Average SiO_2	$(Al_2O_3+TiO_2)$%	Average $Al_2O_3+TiO_2$	Fe_2O_3%	Average Fe_2O_3	L.O.I.%	CaO%	MgO%	TiO_2%
a		25	61.62		26.17		2.11		8.69	0.75	0.28	n.d.
/b	II	100	46.97	50.00	37.27	35.14	1.69	1.68	12.98	0.55	0.18	n.d.
/c		30	50.42		35.52		1.30		11.75	0.50	0.17	n.d.
/a		35	46.79		37.26		1.70		13.34	0.30	0.20	n.d.
/b	II	110	48.23	49.09	36.41	35.78	1.68	1.69	12.64	0.40	0.22	n.d.
/c		23	56.69		30.50		1.74		9.87	0.48	0.30	n.d.
/a		40	45.74		38.08		2.10		13.05	0.38	0.23	n.d.
/b	II	105	46.11	47.04	38.20	37.43	1.72	1.81	12.87	0.50	0.24	n.d.
/c		20	54.53		32.09		1.74		10.57	0.51	0.22	n.d.
/a	III	165	64.31	62.66	24.96	25.67	2.24	2.59	8.56	t.	t.	n.d.
/b		40	55.83		28.61		4.04		11.26	t.	t.	n.d.
/a	III	170	57.10	55.97	27.97	28.74	4.03	4.66	10.82	t.	t.	n.d.
/b		150	54.69		29.62		5.38		10.22	t.	t.	n.d.
/a	III	105	56.12	62.53	30.91	25.80	2.24	2.47	10.14	t.	t.	n.d.
/b		105	68.94		20.69		2.69		7.28	t.	t.	n.d.
5/a		40	47.46		36.89		1.67		12.52	0.70	0.25	n.d.
5/b	III	28	46.96	46.88	37.52	37.37	1.38	1.66	12.97	0.60	0.27	n.d.
5/c		90	46.61		37.54		1.74		13.00	0.50	0.19	n.d.
6	III	100	61.78	61.78	27.92	27.92	2.25	2.25	9.03	0.20	0.06	n.d.
7/a		115	50.99		35.01		1.29		11.59	0.60	0.21	n.d.
7/b	III	115	50.36	50.89	35.09	34.83	1.66	1.69	11.99	0.37	0.14	n.d.
7/c		115	51.32		34.39		2.12		11.29	0.40	0.11	n.d.
8/a		110	60.34		27.57		2.10		9.18	0.35	0.12	0.83
8/b	III	110	59.17	58.63	29.27	29.22	1.38	1.85	9.47	0.22	0.08	1.03
8/c		110	56.39		30.82		2.08		10.06	0.68	0.29	0.93
9/a		110	50.55		34.81		1.82		11.52	0.68	0.29	n.d.
9/b	III	110	50.40	50.95	35.16	34.78	2.15	2.01	11.50	0.31	0.13	n.d.
9/c		110	51.89		34.37		2.07		10.89	0.25	0.10	n.d.
0/a		70	49.37		36.50		1.23		11.58	0.60	0.26	n.d.
0/b	III	75	49.38	49.17	36.01	36.07	2.06	2.23	11.31	0.54	0.29	n.d.
0/c		70	48.75		35.69		3.40		11.30	0.30	0.18	n.d.
1/a		125	58.29		29.02		2.01		9.01	0.81	0.42	n.d.
1/b	III	125	50.15	53.28	34.69	32.56	2.14	2.11	11.88	0.52	0.36	n.d.
1/c		125	51.41		33.98		2.19		10.78	0.80	0.44	n.d.
2/a		100	48.24		36.31		1.72		12.52	0.48	0.30	n.d.
2/b	III	110	57.52	53.32	29.78	32.98	2.12	1.71	9.32	0.50	0.32	n.d.
2/c		110	53.76		33.16		1.30		10.49	0.52	0.28	n.d.

.d. = not determined

t. = traces

Table (3): Chemical analysis results of the major oxides for the spot kaolin samples, G. El-Easeila.

Sample number	level	L.O.I.	SiO_2	Al_2O_3 +TiO_2	TiO_2	Fe_2O_3	CaO	MgO
143	I	10.89	54.73	32.27	n.d.	1.79	0.21	t.
144/a	II	11.92	47.52	36.37	n.d.	4.03	0.12	t.
144/b		12.87	49.14	36.71	n.d.	0.89	0.08	t.
144/c		9.75	59.32	28.86	n.d.	1.79	0.13	t.
144/d		12.47	47.94	37.76	n.d.	1.34	0.15	t.
144/e		8.96	60.09	29.61	n.d.	1.34	0.11	t.
144/f		11.45	50.32	35.76	n.d.	2.24	0.09	t.
145/a	III	10.56	56.60	31.31	n.d.	1.34	0.15	t.
145/b		10.88	54.24	31.81	n.d.	1.34	0.95	0.51
146/a	IV	12.19	48.99	36.66	0.92	1.79	0.18	t.
146/b		12.38	49.07	36.11	1.38	2.24	0.16	t.

n.d. = not determined

t. = traces

Table (4): Chemical analysis results of the major oxides for the spot kaolin samples, G. Abu Ediemat.

Sample number	level	L.O.I.	SiO_2	Al_2O_3 +TiO_2	TiO_2	Fe_2O_3	CaO	MgO
147/a	I	10.57	53.81	34.31	n.d.	0.89	0.20	t.
147/b		12.01	48.58	37.56	n.d.	1.34	0.18	t.
147/c		9.95	57.15	31.41	n.d.	1.34	0.12	t.
147/d		11.81	47.86	37.32	n.d.	2.68	0.21	t.
147/e		11.11	52.97	34.56	n.d.	0.89	0.25	t.
148/a	I	8.34	64.13	25.60	1.08	0.90	0.70	0.30
148/b		12.15	49.43	36.21	1.05	1.34	0.60	0.22
148/c		10.86	53.94	32.46	1.07	1.34	0.85	0.24
149/a	I	8.70	63.14	25.11	n.d.	1.79	0.90	0.32
149/b		13.29	45.65	38.21	n.d.	1.79	0.60	0.28
149/c		11.50	52.87	35.21	n.d.	1.34	0.20	0.12
150/a	I	8.72	64.14	25.41	n.d.	0.89	0.55	0.20
150/b		12.88	46.68	38.06	n.d.	1.34	0.70	0.32
150/c		11.99	48.36	37.46	n.d.	1.34	0.30	0.12
151/a	II	11.83	48.96	37.69	n.d.	1.34	0.06	t.
151/b		12.42	47.07	39.27	n.d.	1.79	0.24	t.
151/c		12.79	48.32	36.33	n.d.	1.79	0.27	t.
151/d		11.51	49.68	36.52	n.d.	1.79	t.	t.
152/a	III	10.12	55.41	32.15	n.d.	2.24	t.	t.
152/b		12.19	49.03	35.09	n.d.	3.14	t.	t.
153/a	IV	9.97	56.83	32.00	1.03	0.90	t.	t.
153/b		11.49	52.38	33.84	1.13	2.24	t.	t.

n.d. = not determined

t. = traces

Table (5): The values in ppm of the determined trace elements in kaolin samples.

Sample number	level	locality	B	V	Cr	Cu	Mn	Ni	Co	Sr	Pb	Zn	Zr
143	I	El - Esaila	14	36	50	32	150	32	9	170	32	250	650
101/a	II		12	44	25	12	60	20	10	104	7	95	140
101/b			11	35	21	8	92	12	10	104	9	50	110
101/c			12	43	20	5	120	19	10	104	7	110	305
111/a	III		10	48	74	8	140	15	11	140	12	70	90
111/b			11	43	26	10	115	15	10	138	13	61	99
146/a	IV		19	58	40	22	165	31	10	128	11	95	175
146/b			21	68	85	25	250	42	10	130	21	125	212
148/a	I	Abu Edimat	17	52	18	8	165	20	10	128	7	95	185
148/b			21	52	26	8	160	23	10	140	9	90	150
148/c			20	58	24	13	152	25	11	104	10	70	160
118/a	II		25	63	65	21	77	57	8	104	20	85	230
118/b			12	35	19	17	38	25	11	104	21	40	92
118/c			16	38	16	13	50	21	11	138	13	55	120
138/a	III		14	67	10	18	45	26	9	148	5	110	210
138/b			11	60	14	18	80	35	13	130	7	115	310
138/c			12	62	15	26	80	34	11	150	7	125	360
153/a	IV		26	67	14	35	114	65	8	130	10	125	360
153/b			24	65	15	12	85	26	10	152	9	105	310

Table (6): The values in ppm of the determined trace elements in sandstone (Lower Cretaceous ?) samples.

Sample number	locality	B	V	Cr	Cu	Mn	Ni	Co	Sr	Pb	Zn	Zr
20 E2	El - Esaila	13	52	37	2	850	35	10	160	10	26	90
18 E2		75	60	90	25	400	25	8	130	35	95	310
16 E2		6	34	49	17	12	35	11	190	37	180	330
9 E2		98	42	10	22	290	42	15	190	11	48	315
6 E2		64	68	9	21	260	28	14	200	20	54	250
5 E2		25	62	8	13	22	22	13	162	13	90	200
2 E2		59	47	6	16	250	23	11	200	13	75	220
12 D2	Abu Edimat	14	52	52	21	62	26	10	265	19	90	220
8 D2		38	75	8	26	750	27	13	265	6	26	300
7 D2		17	75	21	33	420	30	11	340	8	67	340
2 D2		6	36	64	13	32	25	10	150	4	60	120

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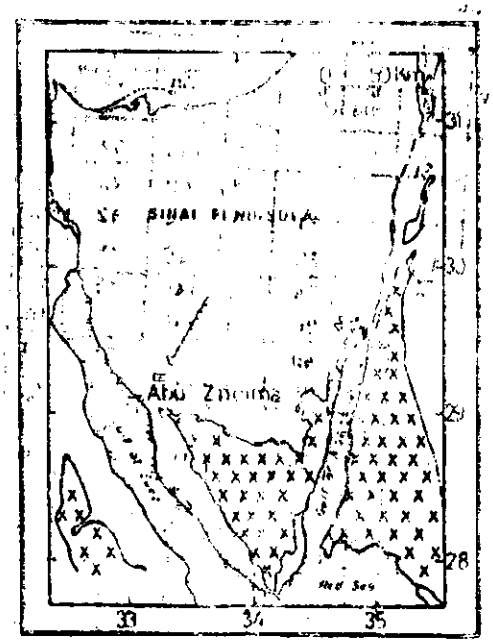


Fig. 1: location map of the study area.

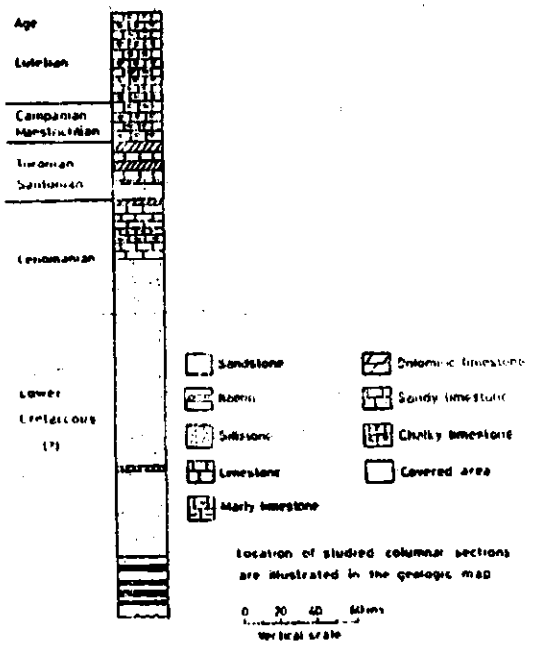
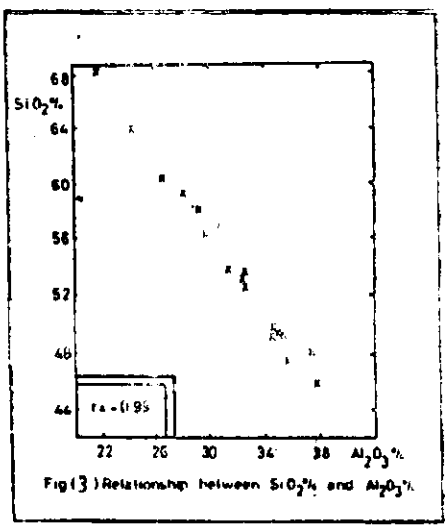


Fig. (2): Composite columnar section for the study area.



Fig(3) Relationship between SiO_2% and Al_2O_3%

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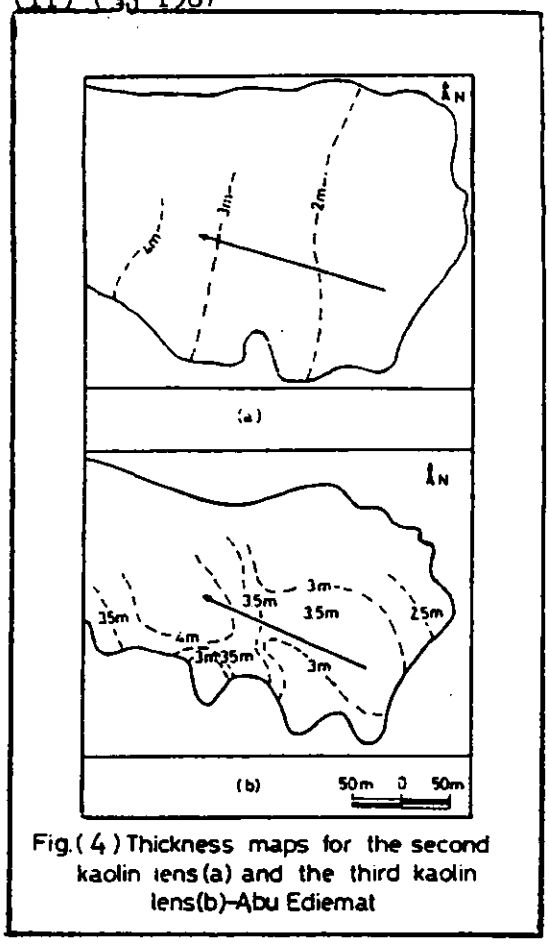

Fig.(4) Thickness maps for the second kaolin lens(a) and the third kaolin lens(b)-Abu Ediemat

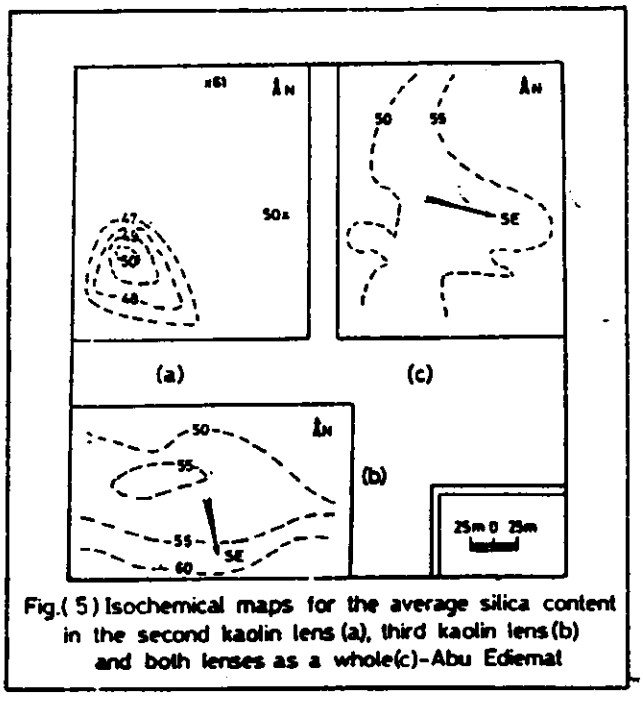

Fig.(5) Isochemical maps for the average silica content in the second kaolin lens (a), third kaolin lens (b) and both lenses as a whole(c)-Abu Ediemat

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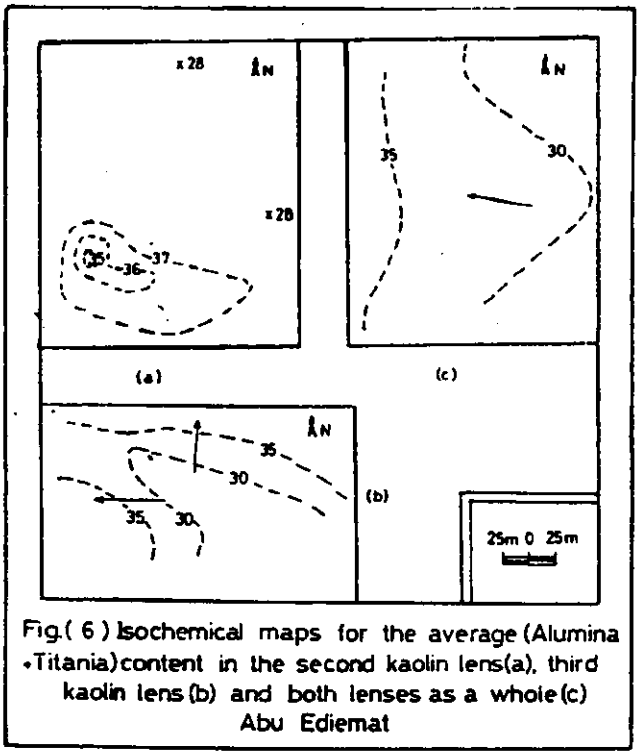

Fig.(6) Isochemical maps for the average (Alumina +Titania)content in the second kaolin lens(a), third kaolin lens (b) and both lenses as a whole (c) Abu Ediemat

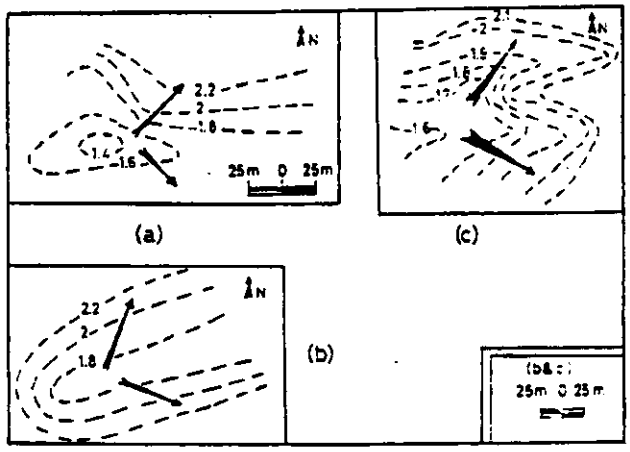

Fig.(7) Isochemical maps for the average Fe_2O_3 content in the second kaolin lens (a), third kaolin lens (b) and both lenses as a whole (c) - Abu Ediemat

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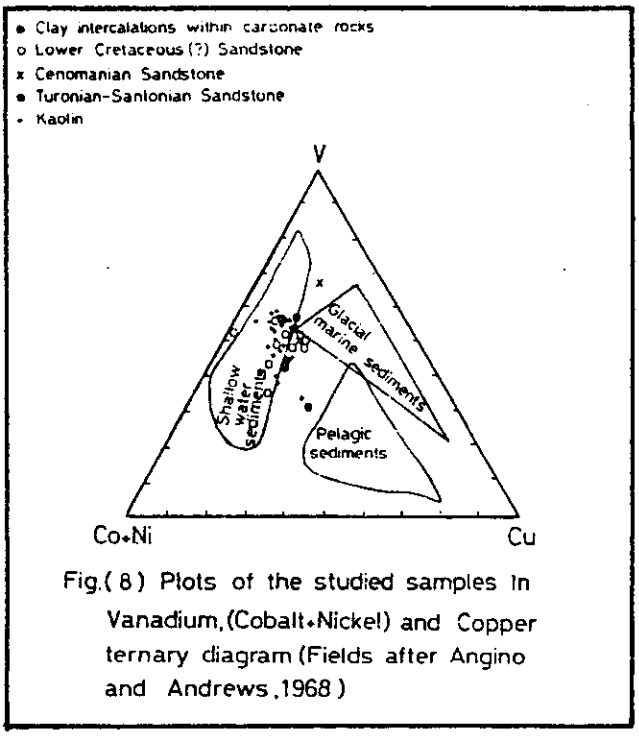

Fig.(8) Plots of the studied samples in Vanadium,(Cobalt+Nickel) and Copper ternary diagram (Fields after Angino and Andrews,1968)

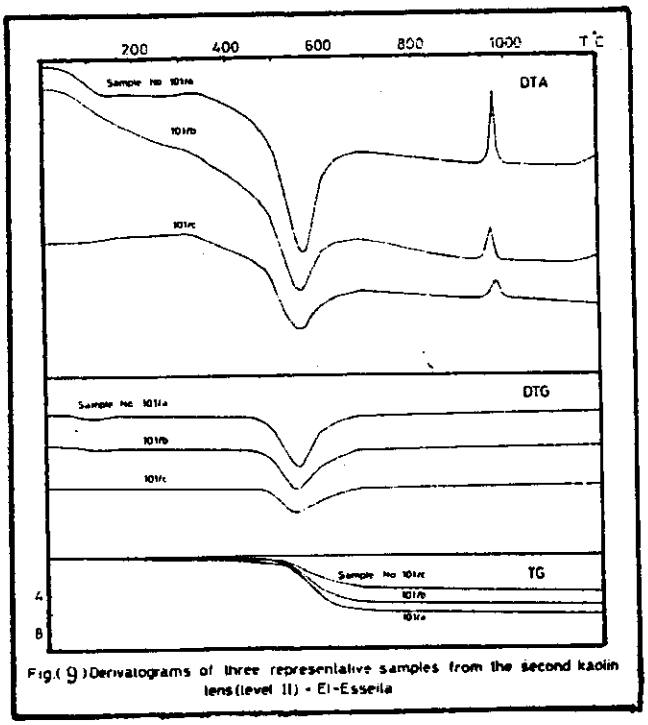

Fig.(9)Derivatograms of three representative samples from the second kaolin lens(level II) - El-Esseila

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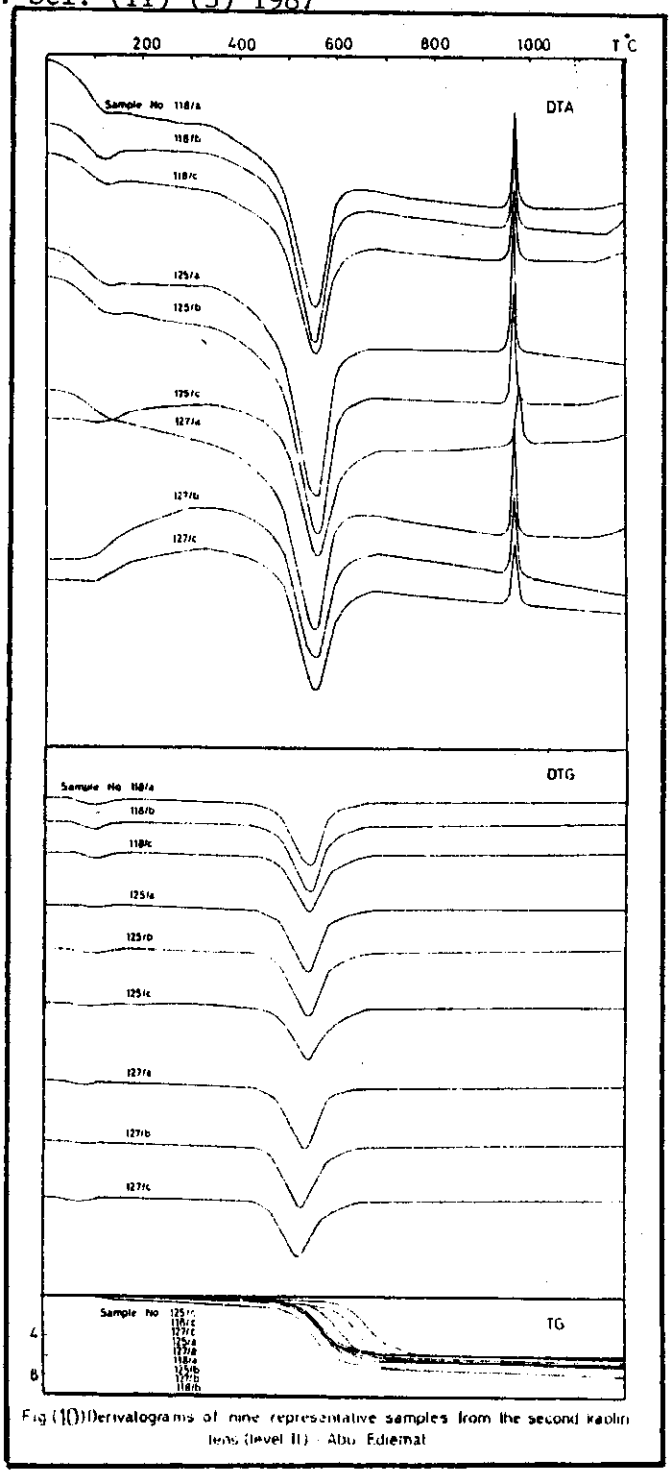

Fig (10) Derivatograms of nine representative samples from the second kaolin lens (level II) - Abu Ediemat

Delta J. Sci. (11) (3) 1987

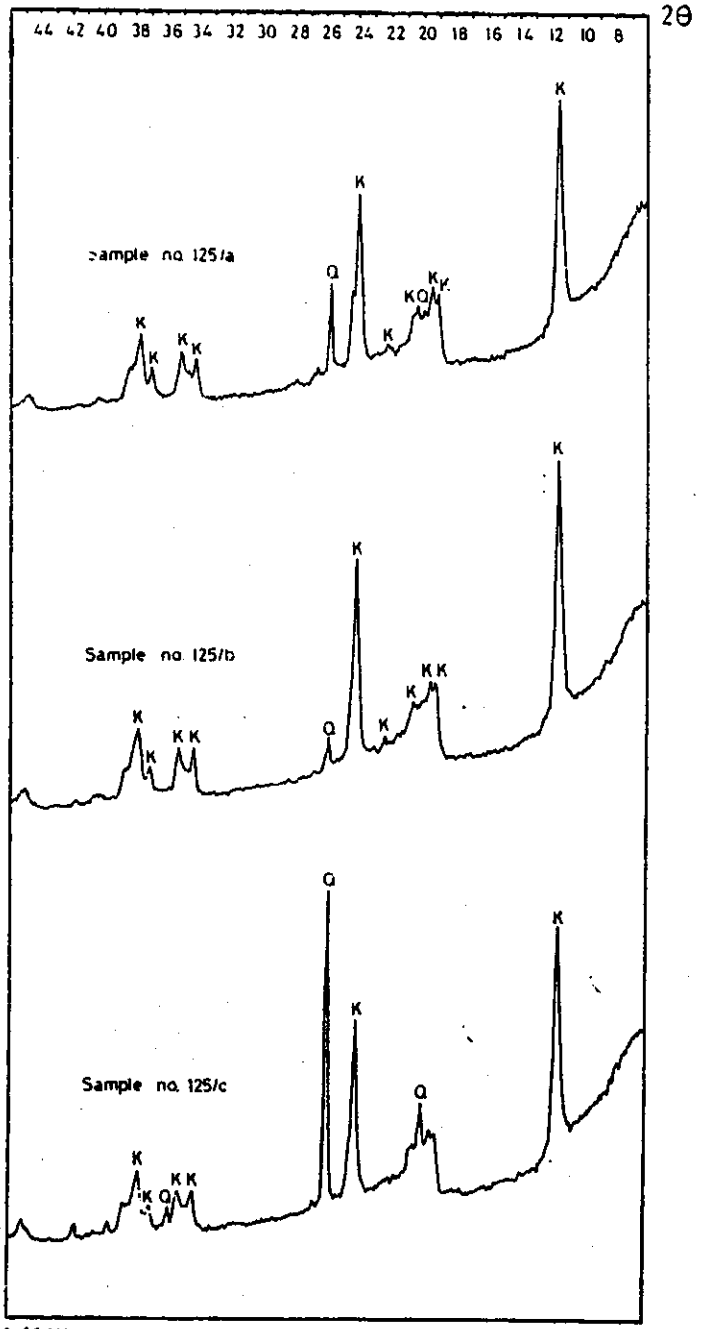

Fig.(11)X-ray diffraction patterns for three representative samples from the second kaolin lens (level II) Abu Ediemat

نشاة والاهميه الاقتصادية لرواسب الكاولين بمنطقة وادى العسيلة وسط غرب سيناء ـ مصر

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يتناول هذا البحث دراسة لبعض طبقات الكاولين بمنطقة وادى العسيله فى وسط غرب سيناء فى محاولة لتحديد اصل وطريقة تكوين هذا الخام ٠ بالاضافة الى تقدير اهمية الاقتصادية ٠

ولقد تم تحليل كيميائى لعدد ١٤٧ عينة لخام الكاولين بالمنطقة بالنسبة للعناصر الرئيسية كما تم اختيار ١٩ عينة منها لتعيين العناصر الشحيحة بالاضافة الى ١١ عينة من صخور الحجر الرملى الحاوى لطبقات الكاولين ٠ اما عن التركيب المعدنى لرواسب الكاولين فقد اوضحت منحنيات التحليل الحرارى التفاضلى والوزنى لعدد ٢٥ عينة كاولين وكذا نظم التشتت الاشعاعى الناتجة من معاملة ٢١ عينة كاولين بالاشعة السينية ان معدن الكاولينيت هو المكون الاساسى لرواسب الكاولين ولا توجد معادن طين اخرى ٠ تضمن البحث كذلك دراسة للمعادن الثقيلة لبعض عينات الحجر الرملى والكاولين لتحديد انواع وخصائص هذه المعادن ٠

ولقد اثبتت هذه التحاليل ان خام الكاولين قد ترسب تحت بيئة مياه ضحلة محتمل ان تكون بيئة بحرية ـ نهرية وان طبقات هذا الخام قد تكونت نتيجة التحلل الكيميائى للمعادن الالومينوسليكاتية (فلسبادات اساسا) بواسطة عوامل التجوية المناسبة فى الصخور الحاملة لها (صخور حمضية كما يستدل على ذلك من القيم المنخفضة عموما لاكسيد الحديديك) وكونت راسبا متبقيا من الكاولين فى الاجزاء العليا لهذه الصخور , ثم نقل الكاولين بعد ذلك بعوامل النقل الى حفر طبقية الشكل تكونت جيومورفولوجيا فى سطح الحجر الرملى النوبى ليترسب فيها ٠ ثم تاتى مرحلة لاحقة ليترسب الحجر الرملى النوبى فوق عدسات الكاولين , وبتكرار هذه العملية تم ترسيب الطبقات المختلفة لخام الكاولين فى فترات زمنية متتابعة ٠

ومن الجدير بالذكر ان العدستان الثانية والثالثة (من اسفل) لكاميرا الكاولين تتميزان بقيمة اقتصادية اكبر من باقى العدسات حيث انهما اعلى جوده وتمتدان لمسافة جانبية اطول وتتمتعان بسمك رأسى كبير.