

8 Summary and Conclusions

The present investigation comprises insights in the mineralogical and geochemical composition of carbonaceous shales from the different geological ages and areas of Egypt.

The study is concerned mainly with:

- 1- the black shale of Ataqa Formation of Carboniferous age in Abu Zinema southwest Sinai,
- 2- the black shale of Safa Formation of Jurassic age in Al Maghara coal mine North Sinai,
- 3- the black shale of Duwi Formation of Upper Cretaceous age in Abu Tartur phosphate mine, Western Desert,
- 4- the carbonaceous and black shales of Duwi Formation, Dakhla Shale and Esna Shale in the Nile Valley area,
- 5- and the black and carbonaceous shales of Duwi Formation and Dakhla Shale in Quseir phosphate mine at Red Sea coast

Mineralogically, the clay minerals of the Ataqa Formation are consisting predominantly of kaolinite with a minor part of illite while the Safa Formation clays consist mainly of detrital kaolinite. The clay minerals of the Duwi Formation in Abu Tartur consist mainly of smectite in addition to different proportions of kaolinite in Quseir and Nile Valley. The Dakhla and Esna shales in Nile Valley consist predominately of smectite in addition to different proportions of kaolinite and chlorite.

The chemical composition of the studied shales shows generally enrichment of elements that are chemically immobile and associated with terrigenous influx, such as SiO_2 , Al_2O_3 , and TiO_2 . The Ataqa and Safa formations show enrichment of zirconium and depletion in CaO which reveals the proximity to the land. On the other hand the studied shales in Abu Tartur, Nile Valley and Quseir show enrichment of CaO.

The studied phosphate samples show enrichment in P_2O_5 , CaO and fluor, which reveal that fluorapatite is the main phosphate mineral in Egyptian phosphate. The low content of detrital terrigenous influx SiO_2 , Al_2O_3 , TiO_2 and Rb, and the association of the phosphate beds with oyster limestone and diatom enrichment in Quseir and in the Nile Valley is indicating the deeper marine origin of the phosphates in the Eastern part of Egypt. The deposition of the phosphatic beds associated with black shales clearly demonstrates a diachronous transgression from the east to the west, starting in the Eastern desert during Lower Campanian and culminating in Upper Campanian and Lower Maastrichtian, covering both, the East and the West, from Quseir, via the Nile Valley towards the Abu Tartur depositional centre.

The distribution of many trace elements has been affected by weathering. The studied shales in Abu Tartur, Quseir and Nile Valley show higher contents of the trace elements Sr, Ba, V, Ni, Cr, Zn, and Rb than shale samples from Abu Zinema and Al Maghara. The Dakhla Shale in Quseir mine shows the highest enrichment of V, Ni, Cr, Zn, and Cu due to the oxidation and weathering of organic matter and subsequent mobilization and concentration of these trace elements. The low trace elements enrichment in the studied phosphate samples indicates leaching processes outgoing from the overlain black shales.

Petrographically the study samples reveal the presence of four lithofacies namely;

- 1- Organic matter-rich black shale facies,
- 2- Foraminifera-rich shales facies,
- 3- Carbonate facies,
- 4- and phosphate facies.

The depletion of Ataqa Formation of Carboniferous age, Safa Formation of Jurassic age and Duwi Formation, in foraminifera and their dark colour as well as the presence of pyrite framboids in Duwi Formation reveal reducing environment of deposition.

The abundance of foraminifera in Dakhla Shale and Esna Shale in Quseir and the Nile Valley give evidence for an oxidation environment of deposition in middle to inner shelf positions. The phosphate samples in Abu Tartur show pelloids of P_2O_5 cemented by carbonate, while the phosphates in the Nile Valley are cemented by silica, an indication for more open marine conditions to the East.

The SEM micrographs show that the kaolinite in Ataqa and Safa formation is of swirly textures with face to face arrangement of coarse detrital kaolinite.

The smectite in Duwi Formation in Abu Tartur show papery structure. The most common forms of pyrite are framboidal and euhedral or masses. There are indications that the trace elements composition of these sediments is influenced by pyrite.

The total organic carbon (TOC) analysis shows high values in the black shales of Safa Formation of Jurassic in Al-Maghara, Ataqa Formation of Carboniferous in Abu Zinema and Duwi Formation of Cretaceous in Abu Tartur and Quseir. The obtained values in Dakhla Shale and Esna Shale show very low values indicating the oxidation of organic matter in outcrop.

The Rock-Eval pyrolysis of the studied shales show that, most of the studied samples are of type III kerogen with low hydrogen index HI due to bad preservation of organic matter. The thermal maturity T_{max} values of the studied shales indicate immature organic matter for hydrocarbon generation.

9 References

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10 Appendix

Appendix A = Table 1 to Table 6b

Appendix B = XRD profiles

Appendix C = Plates of petrography and SEM

Notice:

N = Nile Valley (Esna-Idfu region)

Q = Quseir phosphate mine

AT = Abu Tartur phosphate mine

Mg = Al Maghara coal mine

b.d.l. = below detection limit

< = below

Table 1: Lithological description of the studied samples.

Sample No.	Description
N80	Limestone, white, compact, fossiliferous.
N79	Limestone, as above
N78	Marl, green to light brownish, moderately compact, fractured fossiliferous, evaporitic.
N77	Marl, as above
N76	Limestone, light yellowish, slightly argillaceous, fossiliferous, compact.
N75	Shale, , dark grey, calcareous compact, fractured with veins of evaporites
N74	Argillaceous limestone, yellowish, compact, silty in parts, fractured.
N73	Shale, dark grey, calcareous, moderately hard, ferruginous.
N72	Marl, green to light brownish, moderately hard, ferruginous, trace fossils.
N71	Shale, dark grey, calcareous, moderately hard, silty in parts, ferruginous, with veins of evaporites
N70	Claystone, greenish to yellowish, calcareous, compact, ferruginous spots, evaporitic.
N69	Shale, dark grey, grey to light brownish, calcareous, compact, silty in parts, veins of evaporites.
N68	Shale, as above.
N67	Shale, as above.
N66	Shale, as above.
N65	Shale, as above.
N64	Shale, as above.
N63	Shale, as above.
N62	Shale, as above.
N61	Shale, as above.
N60	Shale, as above.
N59	Shale, marly, grey to yellowish, soft to moderate hardness, silty in parts, lamination, ferruginous.
N58	Shale, marly, as above.
N57	Claystone, grey to light brownish, calcareous, fractured, veins of evaporites
N56	Argillaceous limestone, moderately hard, silty in parts, fractured, evaporitic, ferruginous spots
N55	Claystone, dark grey, calcareous, moderately hard, silty in parts, ferruginous spots, evaporitic
N54	Claystone, grey, calcareous, moderately hard, silty in parts, ferruginous spots, veins of evaporites
N53	Chalky limestone, white to yellowish, compact, fractured with veins of evaporites, silty in parts , fossiliferous.
N52	Chalky limestone, as above.
N51	Argillaceous limestone, grey to light grey, moderate to hard, veins of evaporites.
N50	Argillaceous limestone, as above.
N49	Marl, grey to dark grey, fossiliferous, ferruginous spots, hard, evaporitic, Pecten shells.
N48	Claystone, reddish, ferruginous, calcareous, compact, fractured evaporitic.
N47	Shale, black, dark grey, ferruginous patches and spots between fissiles and through fractures, evaporites, organic remains and traces of shells well preserved, silty in parts..
N46	Shale, as above.
N45	Shale, as above.
N44	Shale, as above
N43	Shale, as above.
N42	Shale, dark grey, alternating with ferruginous siltstone, brownish and reddish, fractured, evaporite lamination between fissiles.
N41	Shale, as above.
N40	Shale, as above.
N39	Claystone, grey to yellowish , calcareous, moderately hard, silty, in parts with gypsum laminae.
N38	Shale, dark grey to brownish, soft hardness, alternating with gypsum lamination, fractured
N37	Shale, black, dark grey to brownish, moderately hard, fractured filled with ferruginous, silty.
N36	Shale, as above.
N35	Claystone, grey to light brownish, moderately hard, ferruginous spots and patches, calcareous, large veins of evaporites.
N34	Shale, black to grey, compact, calcareous, veins of evaporite, patches of ferruginous through fractures and between sheets.
N33	Shale, black, moderately hard, fractured, ferruginous patches, few evaporite, calcareous.
N32	Shale, as above.
N31	Shale, grey to brownish, calcareous , moderate to soft, veins of evaporites, ferruginous

Table 1: cont.

Sample No.	Description
N30	Shale , as above
N29	Shale , black to dark grey compact, ferruginous patches evaporite, calcareous.
N28	Shale , dark grey to brownish, moderately hard, less orites, ferruginous patches and spots embedded.
N27	Shale , as above.
N26	Shale , black to grey, medium hard, fractured, ferruginous patches, reddish to brownish veins of evaporite, salts and calcareous.
N25	Shale , grey with red hematitic siltstone as lenses and tubes, moderately hard, evaporite embedded between shale, siltstone
N24	Phosphat , yellow to light brownish, highly fossiliferous, less hardness, organic matter and bones remains, cherty nodules.
N23	Oyster limestone , greyish, very compact, fractures filled with calcite and rock fragments
N22	Argillaceous limestone , yellow, very compact, patches of organic matter.
N21	Dolomitic limestone , grey, very compact.
N20	Phosphate , yellow to light brownish, highly fossiliferous, less hardness, organic remain, highly calcareous
N19	Conglomerate bed , light brownish, very compact, calcareous, phosphatic.
N18	Sandstone , grey to light brownish, moderately hard, lamination of sand, silt and claystone, fractured, evaporitic
N17	Claystone , grey, medium hard, silty, fissiles, fractured, veins of evaporite
N16	Phosphate , brownish, to yellowish, compact, fossiliferous, ferruginous, with sandy and chert nodules.
N15	Siltstone , grey, brown to yellowish, alternating with claystone, fissil, medium hard, ferruginous patches interbedded change the colour to yellowish, brownish
N14	Sandstone , yellow, moderately hard, ferruginous.
N13	Claystone , yellowish to light brown, silty, compact, fissil fractured with black patches of organic matter and evaporites
N12	Phosphate bodies , with conglomerate and breccia, yellow to brownish, compact, ferruginous.
N11	Siltstone , brown to reddish surrounding the phosphate nodules
N10	Claystone/Siltstone , brownish to grey, medium hard, rare evaporites, slightly fissil.
N9	Claystone , green, moderately hard, silty in parts, slightly fissiles with evaporites interclation
N8	Siltstone , grey, yellowish, brownish lamination, moderately hard, sandy in parts, iron concretion, ferruginous, and few evaporites
N7	Claystone , green, moderately hard, fractured with rare evaporites.
N6	Siltstone , brownish, ferruginous, calcareous, moderately hard, with embedded veinlets of sandstone, cross laminated, few evaporite laminae are interbedded also
N5	Siltstone , green to brownish, moderately hard, slightly calcareous, sandy in parts, slightly fissiles.
N4	Siltstone , reddish brown, ferruginous moderately hard and with rare evaporites
N3	Claystone , green to grey, silty in parts, with rare evaporites.
N2	Siltstone , brownish, ferruginous, sandy in parts
N1	Claystone , dark grey, silty in parts, rare evaporites and ferruginous spots
Q1	Shale , black, subfissil, highly carbonaceous, pyritic.
Q2	Marl , yellowish brown, compact.
Q3	Phosphate , yellow to light brownish, highly fossiliferous, less hardness, organic matter and bone remains, cherty nodules.
Q4	Phosphate , silicified, yellow brownish, compact, organic matter, bone remains, cherty nodules
Q5	Oyster limestone , greyish, very compact, fractured.
Q6	Shale , grey to yellowish, calcareous, micaceous, slightly fissiles.
Q7	Shale , brownish, micaceous, fissile, gypsiferous, slightly calcareous.
Q8	Shale , black to grey, compact, subfissile, alternated with gypsum laminae.
Q9	Shale , as above.
Q10	Shale , black, weathered.
Q11	Shale , pale brown, fossiliferous, highly calcareous, fissile
Q12	Shale , as above
Q13	Shale , pale brown, fossiliferous, highly calcareous, fissile, gypsiferous.
Q14	Shale , as above.
Q15	Shale , pale brown, grey, fossiliferous, highly calcareous

Table 1: cont.

Sample No.	Description
Q16	Shale, as above.
Q17	Shale, black, weathered.
Q18	Phosphate, silicified, yellow to light brownish, organic matter and bone remains, cherty nodules.
Q19	Phosphate, yellow to light brownish, compact, organic matter and bone remains.
Q20	Marl, yellowish brown, compact.
Q21	Oyster limestone, greyish, very compact, fractured.
Q22	Phosphate, yellow to light brownish, highly fossiliferous.
Q23	Shale, pale brown, grey, fossiliferous (pecten), highly calcareous
Q24	Shale, as above.
Q25	Shale, as above.
Q26	Shale, as above.
Q27	Shale, black, weathered.
Q28	Shale, grey to greenish grey, fissile, gypsiferous, slightly compact.
Q29	Shale, as above.
Q30	Shale, as above
Q31	Phosphate, yellow, brownish, compact, organic matter and bones remains, highly calcareous
Q32	Shale, pale brown, grey, fossiliferous, highly calcareous.
Q33	Shale, as above
Q34	Shale, as above
Q35	Shale, black, weathered.
AT1	Shale, black, compact, subfissil, pyritic, slightly gypsiferous
AT2	Shale, as above
AT3	Shale, as above
AT4	Phosphate, black, calcareous, slightly compst.
AT5	Phosphate, black, calcareous, slightly compst.
AT6	Shale, as above
AT7	Shale, as above
AT8	Phosphate, black, calcareous, slightly compst
AT9	Phosphate, black, calcareous, slightly compst, fissile to sub fissile.
AT10	Shale, as above
AT11	Shale, as above
AT12	Phosphate, black, calcareous, slightly compst.
Mg1	Shale, black, compact, highly carbonaceous, ferruginous
Mg2	Shale, as above
Mg3	Shale, as above
Mg4	Shale, as above
Mg5	Shale, as above
AZ1	Shale, black, gypsiferous, fissile, highly carbonaceous.
AZ2	Shale, as above
AZ3	Shale, as above
AZ4	Shale, black, gypsiferous, fissile, highly carbonaceous
AZ5	Shale, as above
AZ6	Shale, as above
AZ7	Shale, as above
AZ8	Shale, as above
AZ9	Shale, as above
AZ10	Shale, as above
AZ11	Shale, as above
AZ12	Shale, as above

Table (2): Semiquantitative mineralogical composition of clay fraction.

Age	Formation	Location	S.No	Smectite	Kaolinite	Chlorite	Illite
Late Maastrichtian - Early Eocene	Esna Shale	Nile Valley (Esna -Idfu) region	N79	95	5	0	0
			N78	90	0	10	0
			N75	98	2	0	0
			N73	95	0	5	0
			N72	97	0	3	0
			N71	95	5	0	0
			N69	71	0	29	0
			N66	70	0	30	0
			N64	93	7	0	0
			N60	62	Trace	38	0
			N55	100	0	0	0
			Avg.	88	2	10.	0
Late Maastrichtian-Middle Paleocene	Dakhla Shale	Nile Valley (Esna -Idfu) region	N47	93	7	0	0
			N43	58	0	42	0
			N41	55	0	45	0
			N37	83	17	0	0
			N35	35	0	65	0
			N33	86	14	0	0
			N31	68	Trace	32	0
			N29	88	12	0	0
			N27	78	22	Trace	0
			N26	86	14	0	0
			Avg.	73	9	18.	0
			Campanian-Maastrichtian	Variegated, Duwi	Nile Valley (Esna -Idfu) region	N17	92
N15	85	0				15	0
N10	90	0				10	0
N9	70	Trace				30	0
N5	65	Trace				35	0
N1	98	2				0	0
Avg.	83.	0				16.	0
Maastrichtian	Duwi and Dakhla	Quseir Mines	Q.1	98	2	0	0
			Q.7	94	6	0	0
			Q.9	33	67	0	0
			Q.11	84	16	Trace	0
			Q.14	88	12	0	0
			Q.16	92	8	0	0
			Q.20	85	15	0	0
			Q.23	94	6	0	0
			Q.26	97	3	0	0
			Q.32	80	20	0	0
			Q.34	34	66	0	0
			Avg.	80	20.	0	0
Maastrichtian	Duwi	Abu Tartur Mine	AT.2	99	1	0	0
			AT.5	100	0	0	0
			AT.7	100	Trace	0	0
			AT.9	100	Trace	0	0
			Avg.	100	0	0	0
Middle Jurassic	Safa	Maghra Mine	Mg.1	0	100	0	0
			Mg.3	Trace	100	0	0
			Mg.5	0	100	0	0
			Avg.	0	100	0	0
Carboniferous	Ataqa	Abu Zenima	AZ.1	0	100	Trace	Trace
			AZ.5	0	60	0	40
			AZ.8	0	100	0	0
			Avg.	0	87	0	13

Avg =average

Table (3): Semiquantitative mineralogical composition of bulk studied samples.

Age	Formation	Location	Sample No	Quartz	Feldspare	Calcite	Dolomite	Anhydrite	F-apatite	Iron oxides	Halite	Gypsum	Clay			
Late Paleocene – Early Eocene	Esna Shale	Nile Valley (Esna- Idfu) region	N79	13	0	5	0	35	0	0	0	0	47			
			N78	5	0	25	1	1	0	0	9	0	59			
			N77	6	0	24	54	0	0	0	0	0	0	16		
			N75	12	0	0	0	0	0	0	0	0	0	88		
			N74	10	0	68	0	14	0	0	0	0	0	8		
			N73	9	0	0	0	0	0	0	0	0	0	91		
			N72	11	0	22	0	7	0	0	0	0	1	59		
			N71	8	0	0	0	12	0	0	0	0	0	80		
			N70	7	0	27	0	19	0	0	0	0	0	47		
			N69	8	0	26	0	3	0	0	0	0	0	63		
			N68	9	0	2	0	17	0	0	0	0	0	72		
			N67	8	0	0	3	16	0	6	0	0	0	67		
			N66	6	0	5	0	0	0	0	0	0	0	89		
			N65	6	0	39	0	1	0	0	0	0	0	54		
			N64	6	0	15	50	2	0	0	0	0	0	27		
			N63	8	0	37	0	16	0	0	0	0	0	39		
			N62	6	0	5	0	26	0	0	0	0	0	63		
			N60	10	0	0	0	0	0	0	0	0	0	90		
			N59	0	0	8	81	0	0	0	0	0	0	11		
			N58	8	0	13	0	4	0	0	0	0	0	75		
			N57	6	0	29	0	24	0	0	0	0	0	41		
			N56	5	0	79	0	10	0	0	0	0	0	6		
			N55	16	0	52	0	7	0	0	0	0	0	25		
			Avg.	8		21	8	9	0	0	0	0	0	53		
			Middle Paleocene	Tara wan	N52	6	0	0	0	94	0	0	0	0	0	0
					N50	3	0	56	0	41	0	0	0	0	0	0
Avg.	4.5				0	28	0	68	0	0	0	0	0	0		
N49	7				0	88	0	0	0	0	0	0	0	5		
N47	30				0	0	0	0	0	10	0	0	0	60		
N46	23				0	0	0	7	0	0	0	0	0	70		
N45	28				3	0	0	0	0	0	0	0	0	69		
N44	17				0	0	0	29	0	13	0	0	0	41		
N43	19				0	0	0	0	0	29	0	0	0	52		
N42	22				0	0	0	0	0	0	0	0	0	78		
N41	20				5	3	0	0	0	0	0	0	0	72		
Late Maastrichtian-	Dakhla				N39	47	9	0	0	4	0	0	0	0	0	40
					N37	7	0	0	0	44	0	5	0	0	0	44
					N36	17	6	6	0	16	0	7	0	0	0	48
			N35	0	0	0	0	84	0	0	0	0	0	16		
			N34	19	0	0	0	0	0	7	0	0	0	74		
			N33	23	3	0	0	0	0	0	0	0	0	74		
			N32	21	3	0	0	0	0	0	0	0	0	76		
			N31	14	1	0	0	0	0	0	0	0	0	85		
			N30	24	1	0	0	0	0	0	0	0	0	75		
			N29	16	3	0	0	0	0	39	0	0	0	42		
			N28	10	4	0	0	0	0	0	0	0	0	86		
			N27	17	0	42	3	0	0	2	0	3	0	33		
		N26	20	4	0	0	0	0	0	0	0	0	76			
		Avg.	19	2	7	0	9	0	5	0	0	0	60			
Campanian -Maastrichtian	Vanegated- Duwi	N24	40	0	13	0	0	47	0	0	0	0	0			
		N21	5	0	95	0	0	0	0	0	0	0	0			
		N20	18	0	4	0	0	78	0	0	0	0	0			
		N17	4	0	0	76	0	0	0	0	0	2	18			
		N15	17	0	0	46	0	0	0	0	0	0	37			
		N13	33	4	0	0	10	0	16	0	1	0	36			
		N12	45	10	0	0	11	0	0	0	0	0	34			
		N10	53	31	0	0	0	0	0	0	0	0	16			
		N9	42	15	0	0	0	0	0	0	0	0	43			
		N7	64	5	0	0	13	0	0	0	0	0	18			
		N5	64	19	0	0	0	0	0	0	0	0	17			
N1	75	15	0	0	0	0	0	0	0	0	10					
Avg.	33	8	9	10	2	10	1	0	0	0	19					

Avg =average

Table (3): cont.

Age	Formation	Location	Sample No	Quartz	Feldspar	Calcite	Dolomite	Anhydrite	F-apatite	Iron oxides	Pyrite	Gypsum	Clay	
Late Maastrichtian - Middle Paleocene	Duwi and Dakkha Shale	Quseir Mines	Q 1	33	0	0	0	0	0	0	2	1	64	
			Q 2	19	0	0	51	0	30	0	0	0	0	
			Q 4	47	0	0	12	0	14	0	0	0	0	0
			Q 6	0	0	0	0	0	53	0	0	0	47	0
			Q 9	14	0	52	0	0	0	0	0	0	34	0
			Q 10	43	0	0	0	0	0	0	0	4	4	49
			Q 11	27	0	54	0	0	10	0	0	0	0	9
			Q 14	18	0	61	0	0	0	8	0	0	0	13
			Q 15	29	0	56	0	0	0	0	0	0	0	15
			Q 16	30	0	56	0	0	0	0	0	0	0	14
			Q 17	19	0	68	0	0	0	0	0	1	0	12
			Q 19	9	0	0	51	0	40	0	0	0	0	0
			Q 20	50	4	0	0	0	0	5	0	0	0	41
			Q 21	3	0	83	14	0	0	0	0	0	0	0
			Q 22	6	0	54	0	0	40	0	0	0	0	0
			Q 23	40	0	0	0	0	32	0	0	0	0	28
			Q 26	20	0	38	0	0	0	0	0	0	0	42
			Q 27	14	0	48	0	0	21	0	3	2	12	0
			Q 31	8	0	40	0	0	52	0	0	0	0	0
			Q 32	74	0	0	0	0	0	0	0	0	6	20
Avg.	25	0	31	6	0	15	1	0	5	16	0			
Late Maastrichtian	Duwi	Abu Tartur Mine	AT 1	13	0	0	0	0	0	0	3	0	84	
			AT 2	21	0	0	0	0	0	0	3	1	75	
			AT 3	23	0	0	0	0	0	0	6	1	70	
			AT 4	6	0	0	45	0	44	0	4	1	0	
			AT 5	11	0	0	0	0	0	0	4	1	84	
			AT 6	11	0	0	0	0	0	0	1	3	85	
			AT 7	12	0	0	0	0	0	0	4	1	83	
			AT 8	12	0	0	34	0	49	0	5	0	0	
			AT 9	73	0	0	0	0	0	0	5	0	22	
			AT 10	17	0	0	0	0	0	0	4	1	77	
			AT 11	60	0	0	0	0	0	0	1	0	39	
			AT 12	15	0	0	0	0	74	0	6	6	0	
			Avg.	23	0	0	7	0	14	0	4	1	52	
Middle Jurassic	Safa	Al Maghara Mine	Mg 1	35	0	0	0	0	0	4	1	0	60	
			Mg 2	39	0	0	0	0	0	1	1	0	59	
			Mg 3	49	0	0	0	0	0	0	4	0	47	
			Mg 4	46	0	0	0	0	0	0	0	0	54	
			Mg 5	43	0	0	0	0	0	0	0	0	57	
			Avg.	42	0	0	0	0	0	1	1	0	55	
Carboniferous	Ataqa	Abu Zinema	AZ 1	86	0	0	0	0	0	0	0	0	14	
			AZ 3	75	0	0	0	0	0	0	0	0	25	
			AZ 8	82	0	0	0	0	0	0	0	0	18	
			AZ 9	83	0	0	0	0	0	0	0	0	17	
			AZ 10	73	0	0	0	6	0	0	0	0	21	
			AZ 11	80	0	0	0	0	0	0	0	0	20	
			Avg.	80	0	0	0	0	0	0	0	0	20	

Avg =average

Table(4): Major element composition(wt %) of the studied samples.

Location	Formation	Sample No	SiO ₂ [%]	Al ₂ O ₃ [%]	CaO [%]	MgO [%]	Fe ₂ O ₃ [%]	TiO ₂ [%]	P ₂ O ₅ [%]	Na ₂ O [%]	K ₂ O [%]	SO ₃ [%]	LOI [%]	TotalI [%]	CIA	SiO ₂ /Al ₂ O ₃		
Nile Valley (Esna-Idfu) region	Esna	N79	47.93	16.85	1.02	2.55	7.97	0.86	0.085	1.68	1.16	0.72	19.0	99.21	81	2.84		
		N78	38.63	12.04	8.29	4.27	5.83	0.61	0.191	2.39	0.87	0.41	26.4	99.93	--	3.21		
		N75	57.56	15.42	0.43	3.15	2.94	0.90	0.043	1.77	0.72	0.148	16.90	99.98	84	3.73		
		N72	46.53	13.39	8.68	4.03	5.50	0.62	0.227	1.39	1.00	0.128	18.50	99.99	--	3.47		
		N69	41.20	16.50	7.99	2.17	6.16	0.75	0.096	1.22	0.91	0.195	22.70	99.89	--	2.50		
		N66	46.08	20.51	1.38	1.88	6.01	0.84	0.068	1.31	0.93	0.120	20.80	99.92	85	2.25		
		N60	38.11	16.53	8.43	2.52	5.20	0.57	0.657	2.46	0.91	0.286	24.30	99.97	--	2.31		
	Tarawan	N55	38.97	8.68	15.19	2.31	3.65	0.43	0.175	1.11	0.46	0.140	28.40	99.23	--	4.03		
		N54	18.71	9.67	23.79	0.64	3.36	0.37	0.136	2.34	0.33	0.266	40.30	99.91	--	1.93		
	Dakhla	N52	11.18	5.33	37.99	0.56	2.48	0.25	0.117	0.66	0.24	0.119	41.00	99.92	--	2.10		
		N50	13.88	6.22	33.23	0.70	4.38	0.25	0.234	0.77	0.28	6.2	33.80	100	--	2.23		
		N49	20.34	9.33	28.62	0.90	3.95	0.41	0.212	1.11	0.46	0.126	34.50	99.95	--	2.18		
		N47	42.78	18.13	0.08	1.40	15.25	0.81	0.144	1.51	0.75	1.032	18.00	99.88	89	2.36		
		N45	49.63	19.24	0.03	1.62	4.35	0.99	0.059	1.35	0.59	0.575	21.50	99.93	90	2.58		
		N43	37.46	16.53	0.01	1.66	9.11	0.84	0.102	1.50	0.72	0.313	31.70	98.95	87	2.27		
		N39	46.85	18.24	0.79	1.49	6.01	1.00	0.335	1.53	1.02	0.121	22.60	99.98	84	2.57		
		N37	44.11	22.34	0.36	1.26	4.70	0.96	0.054	0.86	0.47	0.050	24.80	99.96	93	1.97		
		N35	42.19	10.99	18.40	3.16	5.22	0.44	0.108	0.77	0.30	0.570	17.80	99.94	--	3.90		
		N33	48.48	22.36	0.10	0.93	5.40	0.97	0.059	1.33	0.63	0.136	19.60	99.99	91	2.17		
		N31	45.54	21.57	0.10	0.93	8.75	0.91	0.094	1.54	0.59	0.134	19.80	99.65	90	2.11		
		N29	42.51	20.93	0.19	1.30	24.99	0.81	0.123	1.66	0.53	0.266	6.70	98.51	90	2.03		
		N27	38.02	15.86	9.29	2.80	6.08	0.79	0.262	1.70	0.65	0.668	23.82	99.94	58	2.40		
	N26	48.95	22.94	0.28	1.07	6.12	0.98	0.065	1.13	0.66	0.142	17.08	100	92	2.13			
	Duwi	N24	19.21	0.20	29.34	0.30	1.05	0.03	16.78	0.86	0.05	2.173	30.00	99.99	--	96.05		
		N21	18.37	0.49	45.39	0.51	0.86	0.04	0.290	0.18	0.05	0.050	33.77	100	--	37.49		
		N17	48.59	16.17	1.48	1.60	4.93	0.91	0.244	3.15	0.91	1.544	20.47	99.77	74	3.00		
		N15	53.75	11.44	0.60	1.31	3.71	0.83	0.453	1.68	1.09	0.075	25.00	99.93	77	4.70		
		N10	57.94	12.67	0.94	1.11	7.88	0.96	0.673	1.24	1.05	0.296	15.24	99.99	79	4.57		
N9		49.85	18.44	0.24	1.22	4.56	1.28	0.202	1.38	1.55	0.137	21.10	99.95	85	2.70			
N5		55.09	15.25	0.19	1.04	3.42	1.34	0.494	1.38	1.56	0.266	19.95	99.98	83	3.61			
Quseir phosphate mines	Duwi and Dakhla	N1	52.66	17.42	0.13	1.71	7.09	1.27	0.041	1.81	2.98	0.394	14.49	99.99	78	3.02		
		Q 1	45.85	13.57	0.83	2.14	4.77	0.76	0.132	0.36	0.87	2.424	28.00	99.70	87	3.38		
		Q 2	15.10	0.24	23.40	7.59	2.14	0.03	6.219	0.36	0.05	0.929	42.20	98.25	--	62.92		
		Q 7	25.45	7.16	12.33	2.01	5.87	0.44	5.817	7.05	0.83	0.229	32.00	99.16	--	3.55		
		Q 11	37.73	8.83	17.03	1.74	4.88	0.44	3.317	1.16	0.64	0.132	22.28	98.17	--	4.27		
		Q 16	35.39	8.79	21.53	1.41	3.92	0.46	2.600	0.69	0.64	0.136	23.34	98.90	--	4.03		
		Q 18	23.08	0.30	28.15	0.62	0.14	0.03	17.75	0.57	0.05	0.662	27.96	99.31	--	76.93		
		Q 20	49.75	11.81	1.52	1.74	4.88	0.69	0.513	0.44	0.81	0.050	27.40	99.60	81	4.21		
		Q 26	39.32	11.43	16.24	2.41	6.07	0.58	4.897	0.76	0.92	0.213	15.85	98.69	--	3.44		
		Q 31	4.15	0.65	34.35	0.81	0.70	0.03	13.68	1.81	0.05	0.344	40.30	96.87	--	6.38		
		Q 34	19.89	8.55	33.82	0.71	3.00	0.40	0.423	0.38	0.46	0.288	31.70	99.62	--	2.33		
		Abu Tatur	Duwi	AT 2	46.81	14.60	1.18	2.17	5.51	0.78	0.127	0.06	1.39	1.154	26.14	99.92	85	3.21
				AT 4	4.94	1.07	34.09	0.45	3.33	0.06	20.18	0.62	0.06	4.120	29.30	98.22	--	4.62
				AT 5	55.66	17.89	1.79	3.16	6.31	0.87	0.275	0.10	0.93	3.019	9.80	99.80	86	3.11
				AT 7	52.04	16.70	1.85	2.95	6.41	0.82	0.322	0.14	0.88	3.394	14.25	99.75	85	3.12
AT 8	12.00			2.89	28.79	1.26	4.32	0.14	15.90	0.49	0.17	5.087	27.60	98.64	--	4.15		
AT 9	49.77			14.16	1.65	2.33	4.22	0.88	0.303	0.10	1.05	0.836	24.60	99.89	83	3.51		
AT 12	7.73			1.45	30.23	0.39	3.72	0.07	17.26	0.46	0.09	4.606	32.55	98.55	--	5.33		
Al Maghra	Safa	Mg 1	47.01	25.88	0.37	0.90	8.70	1.97	0.093	0.11	0.93	0.543	13.25	99.75	95	1.82		
		Mg 3	49.80	26.43	0.34	0.77	4.28	2.15	0.088	0.11	1.02	0.277	14.50	99.76	95	1.88		
		Mg 5	49.77	26.34	0.35	0.67	6.30	2.25	0.089	0.11	0.86	0.599	12.44	99.77	95	1.89		
Abu Zinena	Ataqa	AZ 1	51.12	18.86	0.29	0.30	0.49	1.14	0.067	0.31	0.94	0.207	26.00	99.72	92	2.71		
		AZ 5	56.23	13.73	0.44	0.30	2.00	1.28	0.043	0.35	1.07	0.517	23.85	99.81	88	4.10		
		AZ 7	57.98	15.37	0.79	0.30	0.23	0.44	0.028	0.11	0.24	0.414	24.20	99.90	93	3.77		
		AZ 8	41.02	20.16	0.16	0.30	0.47	0.94	0.064	1.26	0.51	3.714	30.40	98.99	91	2.03		

Table(5): Trace element composition(ppm) of the studied samples.

Location	Formation	Sample No.	Sr ppm	Ba ppm	V ppm	Ni ppm	Co ppm	Cr ppm	Zn ppm	Cu ppm	Zr ppm	Mn ppm	
Nile Valley	Esna	N79	289	150	180	46	10<	181	119	24	114	46<	
		N78	309	100	160	47	13	150	141	13	90	289	
		N75	248	150	170	22	<10	171	58	22	133	<150	
		N72	362	120	226	93	<10	180	244	21	84	499	
		N69	331	150	196	65	10	197	160	28	110	185	
		N66	211	180	170	48	15	181	154	21	130	<150	
		N60	280	288	170	67	11	166	168	25	91	266	
		N55	428	95	140	78	10	127	159	31	71	131<	
	N54	719	70	110	44	<10	183	75	15	48	<150		
	Tarawan	N52	990	48	83	32	<10	154	43	13	<40	<150	
		N50	703	59	77	36	<10	144	<40	11	44	<150	
	Dakhla	N49	784	62	140	45	<10	222	54	19	52	<150	
		N47	113	60	180	46	25	108	116	21	91	608	
		N45	109	69	190	33	9<	163	61	29	112	<150	
		N43	43	110	170	51	22	111	127	14	97	831	
		N39	158	140	250	46	12	265	90	25	173	<150	
		N37	263	97	170	34	<10	156	68	22	109	<150	
		N35	400	73	140	43	13	153	110	16	55	<150	
		N33	197	73	190	46	11	197	73	27	95	<150	
		N31	54	72	218	64	18	200	195	21	93	<150	
		N29	40	73	202	87	25	192	138	<10	87	1040	
		N27	299	74	197	52	<10	224	96	25	97	<150	
		N26	82	77	210	45	13	215	101	29	97	<150	
	Duwi	N24	1203	362	58	<12	<10	64	65	<10	<40	379	
		N21	208	83	55	<12	<10	50	<40	<10	<40	1770	
		N17	497	120	160	32	8<	174	82	34	99	<150	
		N15	250	264	86	26	<10	77	68	26	297	<150	
		N10	423	339	100	40	<10	100	96	32	336	359	
		N9	562	134	150	19	<10	117	<40	20	236	<150	
		N5	1703	219	100	14	<10	93	<40	22	372	<150	
	N1	78	140	160	41	12	107	65	53	219	<150		
	Quseir Phosphate mines	Duwi and Dakhla	Q 1	76	92	110	41	20	81	69	27	138	195
			Q 2	301	34	45	<12	<10	<30	<40	<10	<40	732
Q 7			470	72	1835	126	<10	379	1250	156	104	<150	
Q 11			486	79	3151	186	<10	631	1600	243	93	<150	
Q 16			513	93	2679	153	<10	414	1130	178	95	<150	
Q 18			951	110	20	<12	<10	35	<40	<10	<40	152	
Q 20			128	110	160	30	<10	123	135	25	146	<150	
Q 26			649	98	1455	177	12	540	1040	154	105	<150	
Q 31			895	53	20	18	<10	100	119	<10	<40	<150	
Q 34			1030	87	110	60	b.d.l	240	61	31	55	<150	
Abu Tarnur	Duwi	AT2	207	110	130	26	12	100	66	16	165	<150	
		AT4	1324	61	46	21	<10	<30	<40	<10	<40	556	
		AT5	226	69	150	31	13	112	41	15	100	<150	
		AT7	300	78	65	39	14	122	44	30	114	<150	
		AT8	1398	64	44	16	10	<30	<40	12	<40	738	
		AT9	296	79	130	36	10	124	53	30	106	<150	
		AT12	1139	58	46	28	9<	58	<40	10	<40	660	
Al Magahra	Safa	Mg 1	110	90	160	68	29	197	92	23	537	785	
		Mg 3	113	100	160	67	25	194	84	30	575	272	
		Mg 5	105	72	160	78	36	199	97	24	571	709	
Abu Zinena	Ataqa	AZ 1	60	140	140	<12	<10	92	<40	37	239	b d l	
		AZ 5	62	140	130	<12	<10	87	<40	22	237	b d l	
		AZ 7	17	47	150	<12	<10	36	b d l.	12	215	b d l	
		AZ 8	48	100	100	26	17	84	224	32	281	<150	

Table(5): Cont.

Location	Formation	Sample No	Mo ppm,	Cd ppm	U ppm	Th ppm	Cs ppm	Pb ppm	Rb ppm	Cr/Ni	Rb/Sr	V/Cr
Nile Valley	Esna	N79	<5	b.d.l.	<5	<10	<8	<15	56	3,93	0,19	1,00
		N78	<5	<5	<5	<10	<8	<15	49	3,19	0,16	1,05
		N75	<5	<5	<5	<10	<8	<15	30	7,77	0,12	0,98
		N72	<5	<5	<5	<10	<8	<15	59	1,94	0,16	1,26
		N69	<5	<5	<5	<10	<8	<15	51	3,03	0,15	0,99
		N66	<5	<5	<5	13	<8	<15	59	3,77	0,28	0,93
		N60	<5	<5	7	<10	<8	<15	52	2,48	0,19	1,01
		N55	<5	b.d.l.	<5	<10	<8	<15	29	1,63	0,07	1,09
	Tarawan	N54	b.d.l.	<5	<5	<10	b.d.l.	<15	16	4,16	0,02	0,62
		N52	b.d.l.	b.d.l.	6	<10	b.d.l.	<15	12	4,81	0,01	0,54
	Dakhla	N50	<5	b.d.l.	<5	<10	b.d.l.	<15	12	4,00	0,02	0,53
		N49	b.d.l.	<5	<5	<10	<8	<15	19	4,93	0,02	0,61
		N47	<5	<5	<5	<10	<8	16	24	2,35	0,21	1,70
		N45	<5	b.d.l.	<5	<10	<8	<15	26	4,94	0,24	1,16
		N43	<5	<5	<5	<10	b.d.l.	<15	30	2,18	0,70	1,56
		N39	<5	<5	<5	<10	b.d.l.	<15	41	5,78	0,26	0,93
		N37	<5	<5	<5	<10	b.d.l.	16	19	4,59	0,07	1,07
		N35	b.d.l.	<5	<5	<10	b.d.l.	<15	16	3,56	0,04	0,92
		N33	<5	<5	<5	<10	<8	<15	25	4,28	0,13	0,98
		N31	<5	<5	<5	<10	b.d.l.	<15	27	3,13	0,50	1,09
		N29	b.d.l.	382	380	<10	b.d.l.	<15	27	2,21	0,68	1,05
		N27	<5	<5	<5	<10	<8	<15	25	4,31	0,08	0,88
		N26	<5	<5	<5	11	b.d.l.	<15	28	4,78	0,34	0,95
		Duwi	N24	<5	<5	51	b.d.l.	b.d.l.	<15	10	5,33	0,01
	N21		b.d.l.	<5	<5	<10	<8	<15	10	4,17	0,05	1,10
	N17		<5	b.d.l.	<5	<10	<8	<15	35	5,44	0,07	0,90
N15	<5		<5	<5	<10	b.d.l.	<15	29	2,96	0,12	1,12	
N10	<5		b.d.l.	<5	<10	<8	66	29	2,50	0,07	1,04	
N9	<5		<5	<5	<10	<8	<15	48	6,16	0,09	1,26	
N5	b.d.l.		7	<5	<10	<8	<15	41	6,64	0,02	1,11	
N1	<5		<5	b.d.l.	<10	<8	<15	96	2,61	1,23	1,49	
Quser phosphate mines	Duwi and Dakhla	Q 1	<5	b.d.l.	<5	<10	<8	<15	28	1,98	0,37	1,38
		Q 2	9	b.d.l.	27	b.d.l.	b.d.l.	15	10	2,50	0,03	1,50
		Q 7	214	15	52	<10	<8	33	32	3,01	0,07	4,84
		Q 11	474 2	47	41	<10	<8	20	31	3,39	0,06	4,99
		Q 16	258	73	34	<10	<8	29	30	2,71	0,06	6,47
		Q 18	b.d.l.	b.d.l.	24	b.d.l.	b.d.l.	<15	10	2,92	0,01	0,57
		Q 20	<5	<5	9	<10	b.d.l.	<15	32	4,10	0,25	1,28
		Q 26	302	40	44	<10	b.d.l.	30	40	3,05	0,06	2,69
		Q 31	<5	7	27	b.d.l.	b.d.l.	<15	10	5,56	0,01	0,20
		Q 34	<5	b.d.l.	11	<10	b.d.l.	<15	19	4,00	0,02	0,46
Abu Tartur	Duwi	AT 2	<5	<5	<5	<10	<8	<15	23	3,61	0,15	1,32
		AT 4	b.d.l.	<5	21	<10	b.d.l.	<15	<5	1,63	0,00	1,69
		AT 5	<5	b.d.l.	<5	<10	<8	<15	34	3,13	0,09	1,80
		AT 7	<5	9	22	<10	b.d.l.	<15	<5	3,44	0,08	1,61
		AT 8	<5	b.d.l.	<5	<10	<8	<15	27	2,07	0,01	1,12
		AT 9	<5	b.d.l.	<5	<10	b.d.l.	<15	25	3,85	0,11	1,30
Al Magh ara	Safa	AT 12	12	7	27	<10	b.d.l.	<15	6	1,14	0,00	1,92
		Mg 1	<5	<5	<5	19	<8	<15	39	2,90	0,35	0,81
		Mg 3	<5	<5	5	16	<8	<15	44	2,90	0,39	0,83
Abu Zanema	Ataqa	Mg 5	<5	<5	<5	13	<8	<15	37	2,55	0,35	0,78
		AZ 1	<5	<5	<5	19	9	124	51	7,67	0,85	1,49
		AZ 5	<5	b.d.l.	<5	15	<8	95	30	7,25	0,48	1,46
		AZ 7	<5	b.d.l.	<5	<10	<8	b.d.l.	10	3,00	0,59	4,06
AZ 8	<5	6	<5	14	<8	79	20	3,23	0,42	1,24		

Table 6a: Pearsons correlation coefficient values of each pair of elements of the studied shale samples

	SiO ₂	Al ₂ O ₃	CaO	MgO	Fe ₂ O ₃	TiO ₂	P ₂ O ₅	Na ₂ O	K ₂ O	SO ₃	Sr	Ba	V	Ni	Cr	Zn	Cu	Zr	Rb	Cl	F	
SiO ₂	1.00																					
Al ₂ O ₃	0.59	1.00																				
CaO	-0.89	-0.77	1.00																			
MgO	0.21	-0.07	-0.15	1.00																		
Fe ₂ O ₃	0.09	0.33	-0.28	0.16	1.00																	
TiO ₂	0.57	0.79	-0.63	-0.19	0.13	1.00																
P ₂ O ₅	-0.02	-0.36	0.14	-0.13	-0.03	-0.20	1.00															
Na ₂ O	-0.06	-0.03	-0.07	0.27	0.21	-0.20	0.11	1.00														
K ₂ O	0.52	0.28	-0.50	0.18	0.09	0.48	0.08	0.12	1.00													
SO ₃	-0.14	-0.10	0.09	-0.03	-0.05	-0.12	0.00	-0.19	-0.11	1.00												
Sr	-0.41	-0.45	0.49	-0.07	-0.23	-0.24	0.39	0.13	-0.03	0.02	1.00											
Ba	0.36	0.00	-0.27	-0.08	-0.06	0.13	0.62	0.30	0.41	-0.23	0.12	1.00										
V	0.41	0.61	-0.53	0.440	0.46	0.24	-0.21	0.18	0.16	-0.16	-0.40	-0.02	1.00									
Ni	-0.13	0.29	0.00	0.28	0.54	0.15	-0.02	0.21	-0.05	-0.14	-0.12	-0.08	0.46	1.00								
Cr	-0.28	0.30	-0.09	0.11	0.27	0.14	-0.08	0.25	-0.13	-0.21	0.10	-0.17	0.52	0.61	1.00							
Zn	0.00	0.21	-0.16	0.34	0.30	-0.27	0.02	0.41	-0.05	-0.08	-0.24	0.14	0.37	0.64	0.28	1.00						
Cu	0.40	0.33	-0.36	0.00	-0.13	0.38	0.05	0.12	0.57	0.01	-0.13	0.29	0.18	0.03	0.05	0.06	1.00					
Zr	0.46	0.54	-0.43	-0.33	-0.06	0.87	0.00	-0.31	0.35	-0.08	-0.11	0.27	-0.10	0.04	-0.08	-0.08	0.27	1.00				
Rb	0.39	0.35	-0.41	0.31	0.12	0.41	-0.03	0.28	0.82	-0.24	-0.14	0.41	0.33	0.24	0.10	0.28	0.52	0.25	1.00			
Cl	-0.07	-0.21	-0.13	0.03	0.07	-0.11	0.00	0.59	0.01	-0.01	-0.03	0.21	-0.07	-0.10	-0.08	0.31	0.07	-0.10	0.07	1.00		
F	0.02	-0.36	0.13	0.26	-0.11	-0.35	0.35	0.12	0.01	-0.05	0.19	0.48	-0.18	-0.07	-0.23	0.20	-0.05	-0.19	0.12	0.07	1.00	

Table 6b: Pearsons correlation coefficient of each pair of elements of the studied phosphate samples

	SiO ₂	Al ₂ O ₃	CaO	Mg	Fe ₂ O ₃	TiO ₂	P ₂ O ₅	Na ₂ O	K ₂ O	SO ₃	Sr	Ba	V	Ni	Cr	Zn	Cu	Zr	Rb	Cl	F	
SiO ₂	1.00																					
Al ₂ O ₃		1.00																				
CaO			1.00																			
MgO				1.00																		
Fe ₂ O ₃		0.81			1.00																	
TiO ₂		0.98			0.82	1.00																
P ₂ O ₅			0.66				1.00															
Na ₂ O			0.63					1.00														
K ₂ O		0.96			0.74	0.98			1.00													
SO ₃		0.81			0.91	0.82			0.74	1.00												
Sr			0.68				0.93		0.67	0.67	1.00											
Ba	0.50											1.00										
V		0.53				0.62			0.61	0.71			1.00									
Ni		0.96			0.69	0.91			0.91	0.71				1.00								
Cr					0.73										1.00							
Zn															0.86	1.00						
Cu			0.50														1.00					
Zr																0.67		1.00				
Rb																0.64		0.89	1.00			
Cl								0.79							0.70	0.87		0.55	0.58	1.00		
F							0.95				0.82						0.54			0.16	1.00	

Appendix B

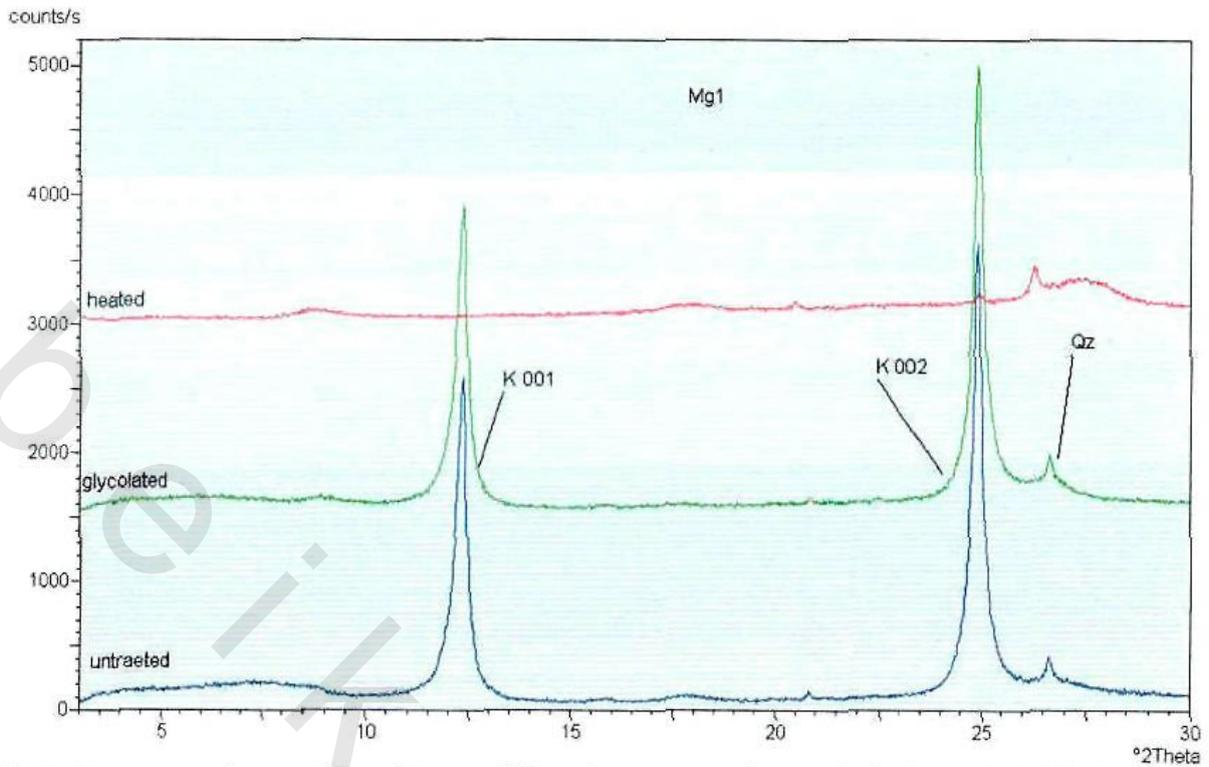


Fig.1: Representative profile of X-ray diffraction patterns for studied clays of Al Maghara coal mine

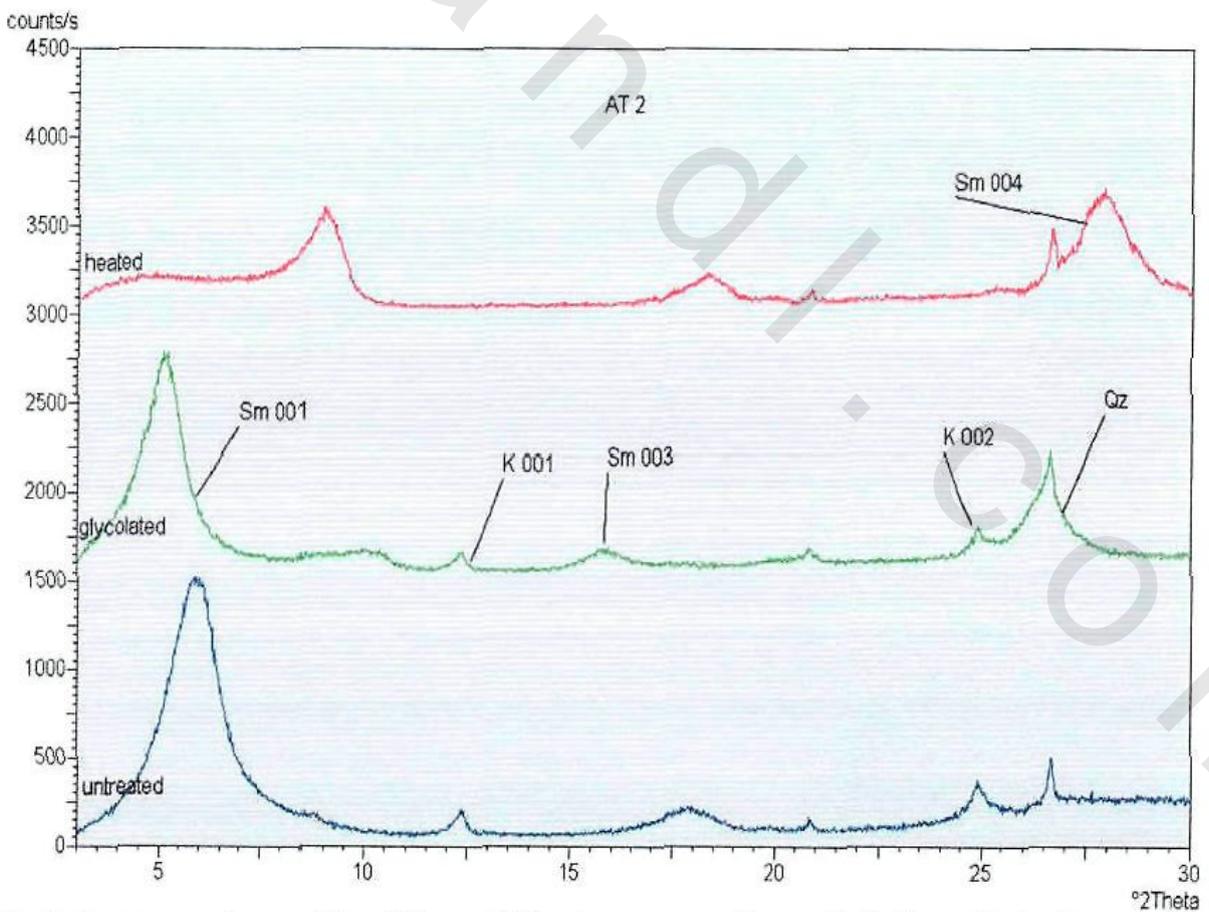


Fig.2: Representative profile of X-ray diffraction patterns for studied clays of Abu Tartur phosphate mine

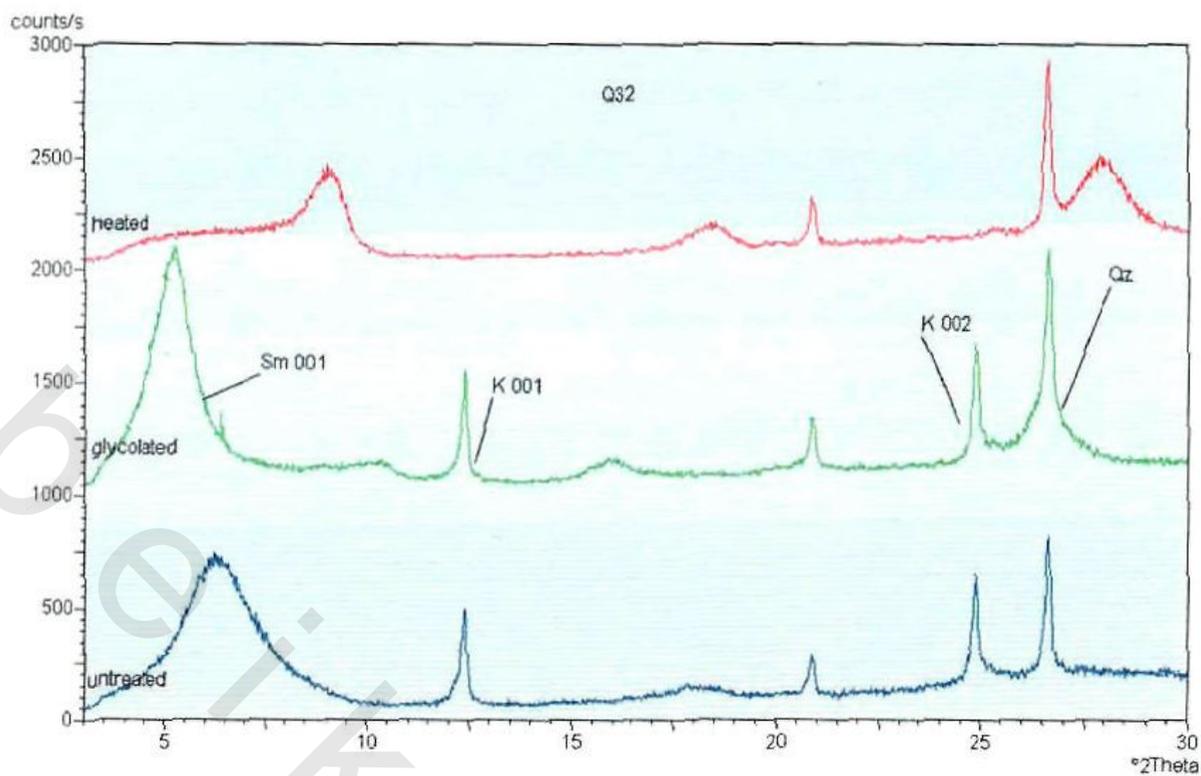


Fig.3: Representative profile of X-ray diffraction patterns for the studied clays of Quseir phosphate mine

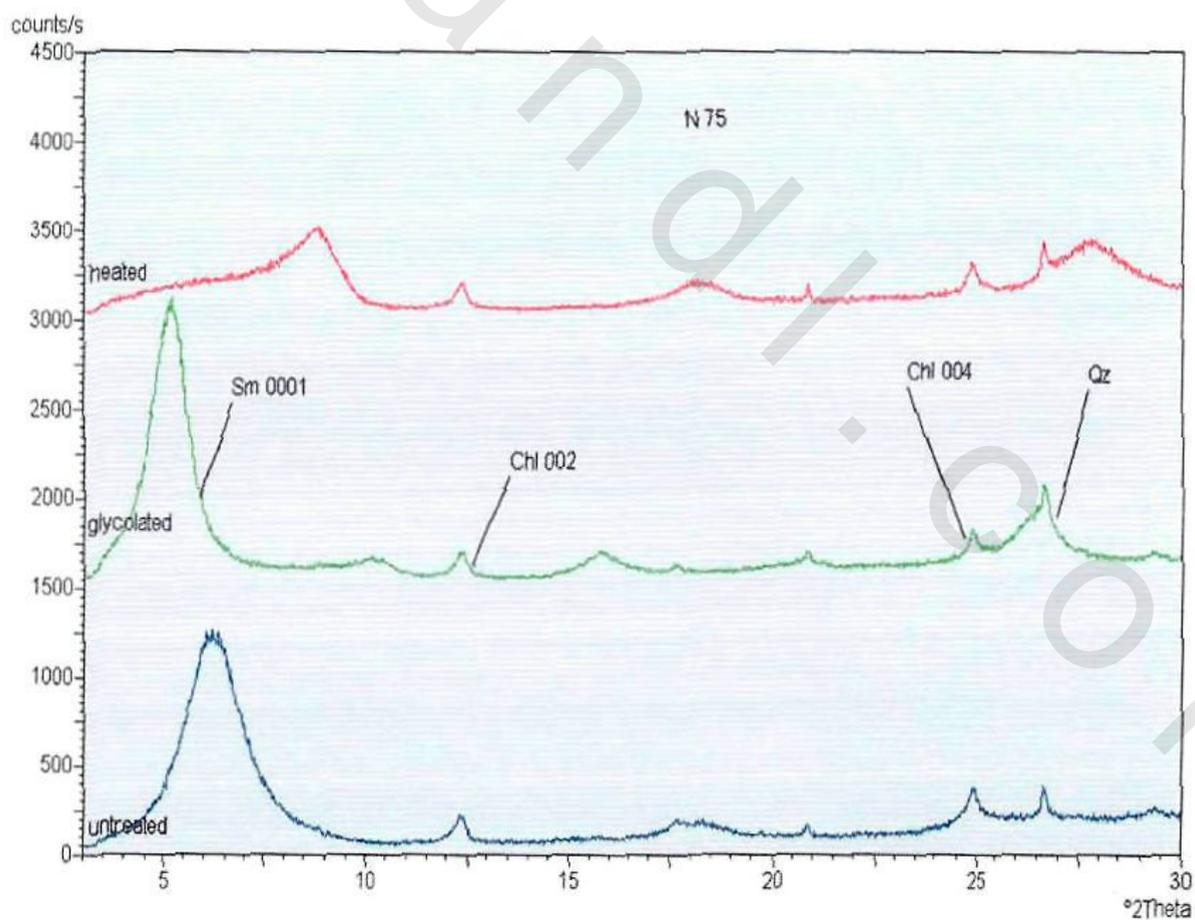


Fig.4: Representative profile of X-ray diffraction patterns for studied clays of Esna-Idfu, Nile Valley.

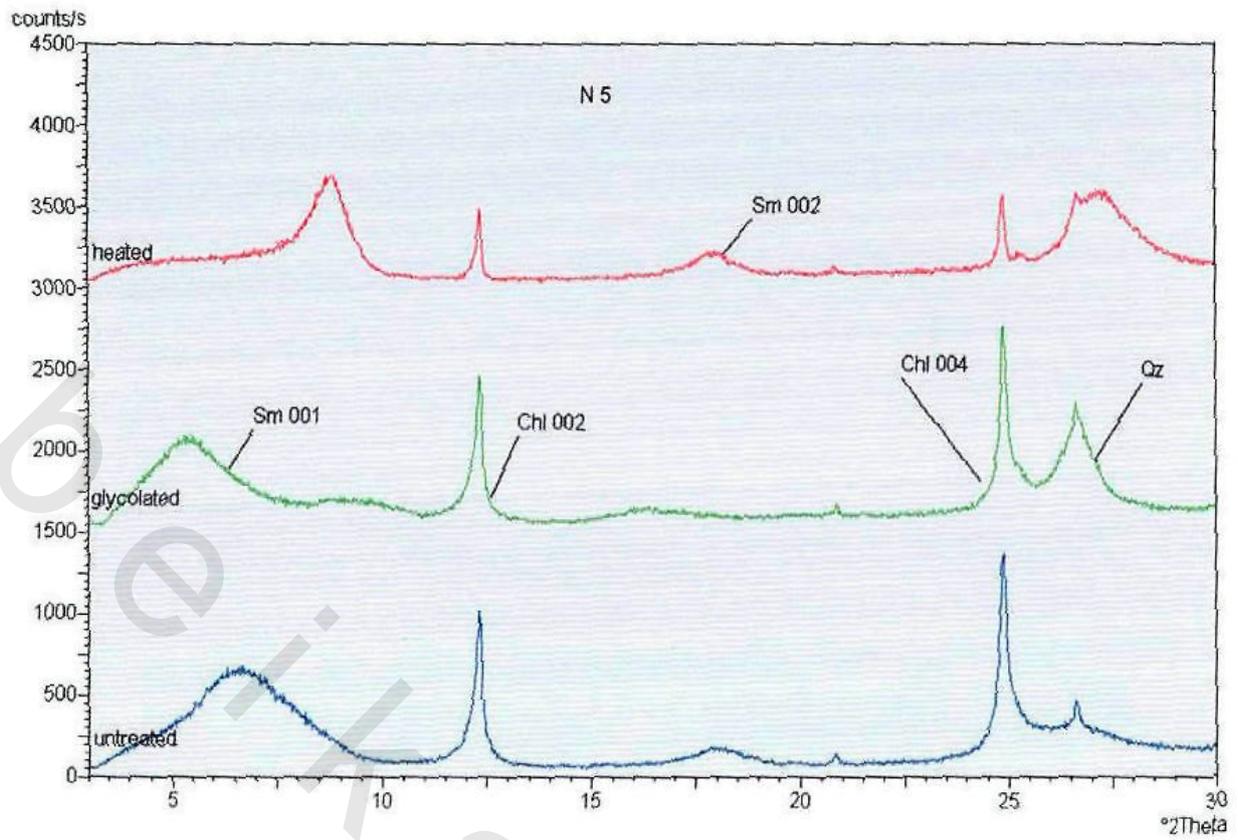


Fig.5: Representative profile of X-ray diffraction patterns for studied clays of Esna-Idfu, Nile Valley.

For abbreviations; Sm: smectite, K: kaolinite, Chl: chlorite, Qz: quartz.

Appendix C

Plate 1

- Fig. A: Photomicrograph of black shale of Duwi Formation in Abu Tartur phosphate mine shows quartz grains, monocrystalline, moderately to well sorted grains.
- Fig. B: Photomicrograph of black shale of Safa Formation in Al Maghara coal mine shows wisps of organic matter.

Plate 2

- Fig. A: SEM micrograph shows swirl texture with face to face arrangement of coarse detrital kaolinite in black shale of Safa Formation in Al Maghara coal mine.
- Fig. B: SEM micrograph shows swirl texture with face to face arrangement of coarse detrital kaolinite and detrital platelets of kaolinite with irregular edges in black shale of Ataqa Formation in Abu Zinema.

Plate 3

- Fig. A: Photomicrograph of black shale of Duwi Formation in Abu Tartur phosphate mine shows silty claystone.
- Fig. B: SEM micrograph shows smectite particles, have expanded, flored "cornflak" or "Okal leaf" like structure, in Duwi Formation in Abu Tartur phosphate mine.

Plate 4

- Fig. A: SEM micrograph showing the aggregates of euhedral pyritic grains in Duwi Formation in Abu Tartur phosphate mine.
- Fig. B: SEM micrograph showing aggregates of framboids of pyrite.

Plate 5

- Fig. A: Photomicrograph showing highly foraminiferal shale in Dakhla Shale in Esna-Idfu, Nile Valley.
- Fig. B: Photomicrograph showing highly foraminiferal shale in Dakhla Shale in Quseir mines.

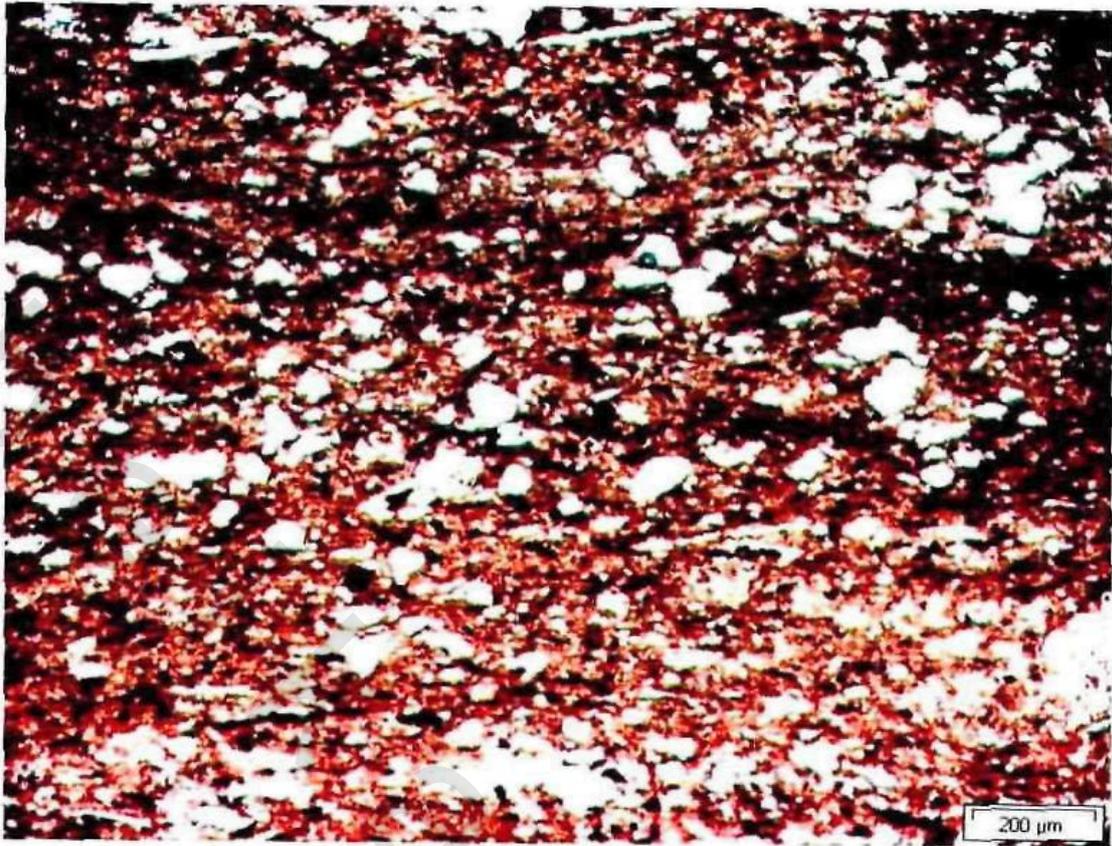
Plate 6

- Fig. A: Photomicrograph showing a micritic, microsparitic or sparitic matrix of the oyster limestone bed in Quseir mine.
- Fig. B: Photomicrograph showing micritic, microsparitic or sparitic, fossiliferous limestone of Tarawan Chalk in Esna-Idfu Nile Valley.

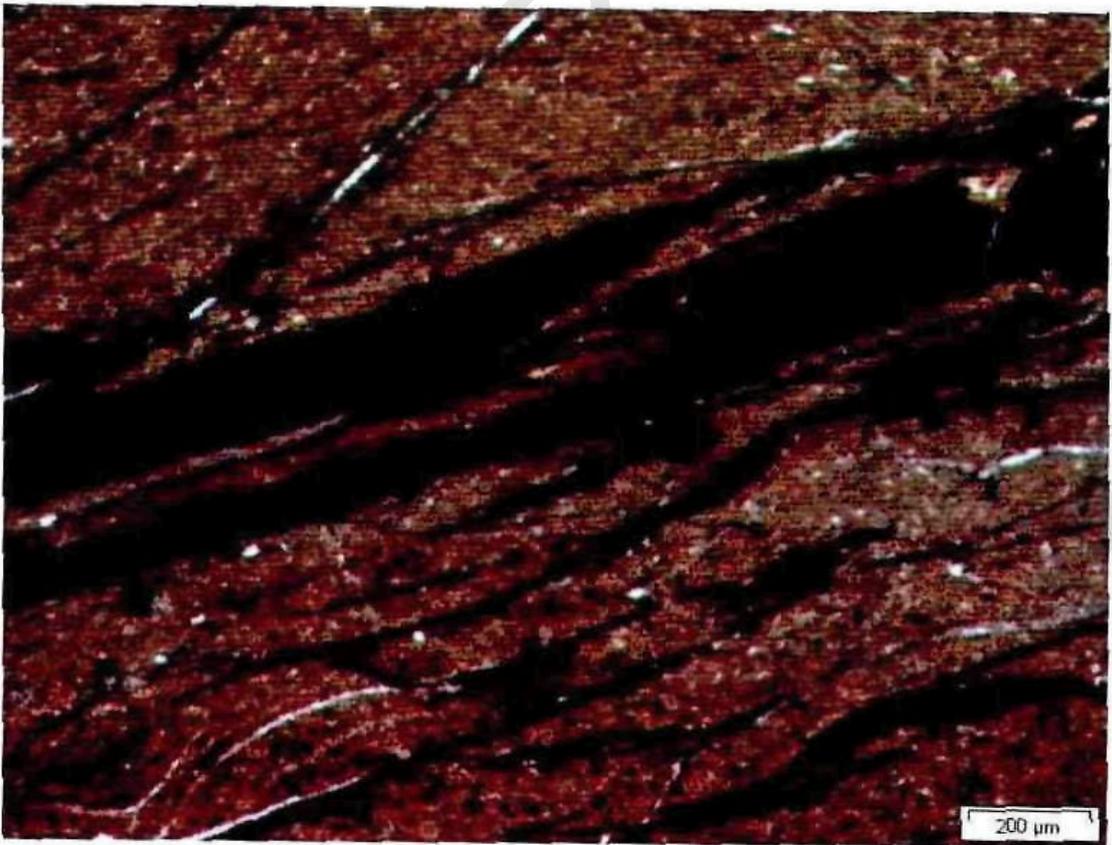
Plate 7

- Fig. A. Photomicrograph showing uncoated phosphate grains in Quseir phosphate mine
- Fig.B: SEM micrograph showing phosphate grains cemented by silica in Duwi Formation Esna-Idfu Nile Valley.
- Fig.C: SEM micrograph showing coated and uncoated phosphate grains cemented by calcite in Duwi Formation in Abu Tartur.

PLATE 1

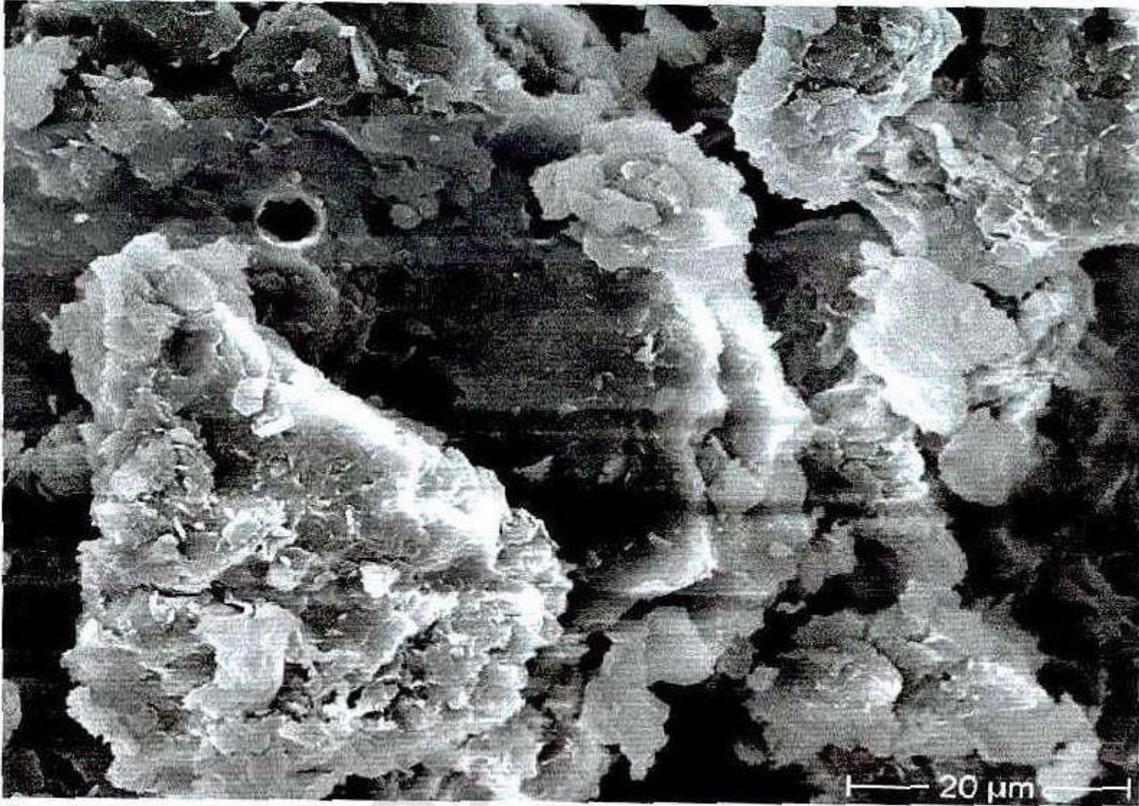


A

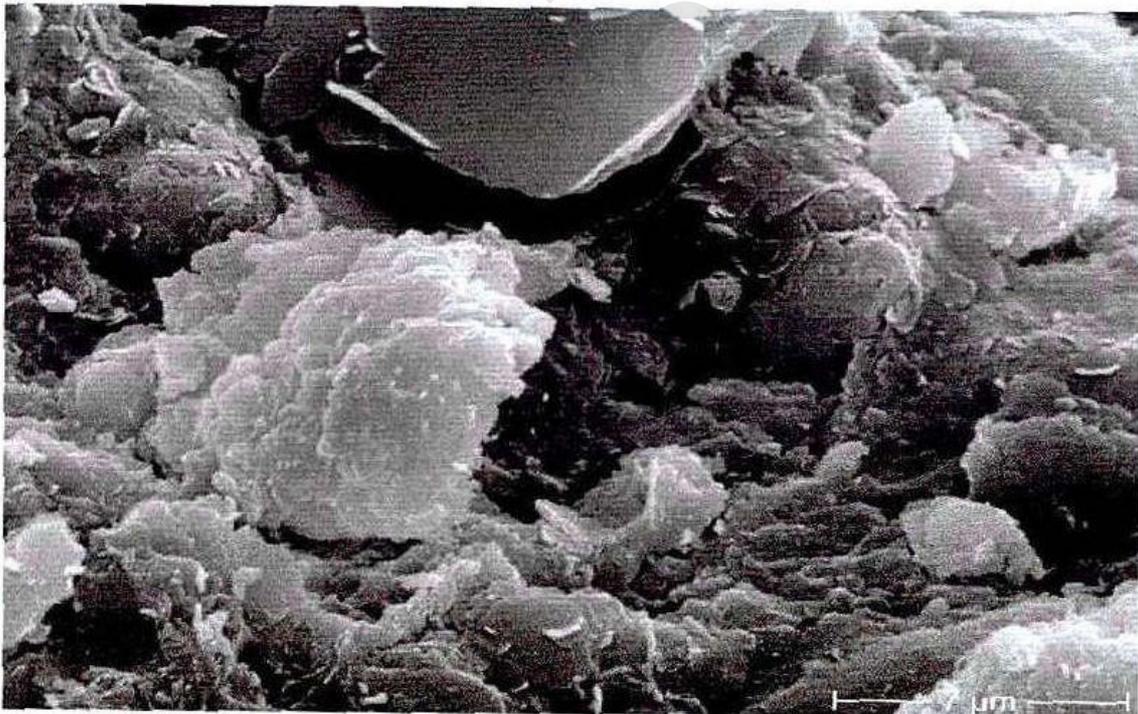


B

PLATE 2

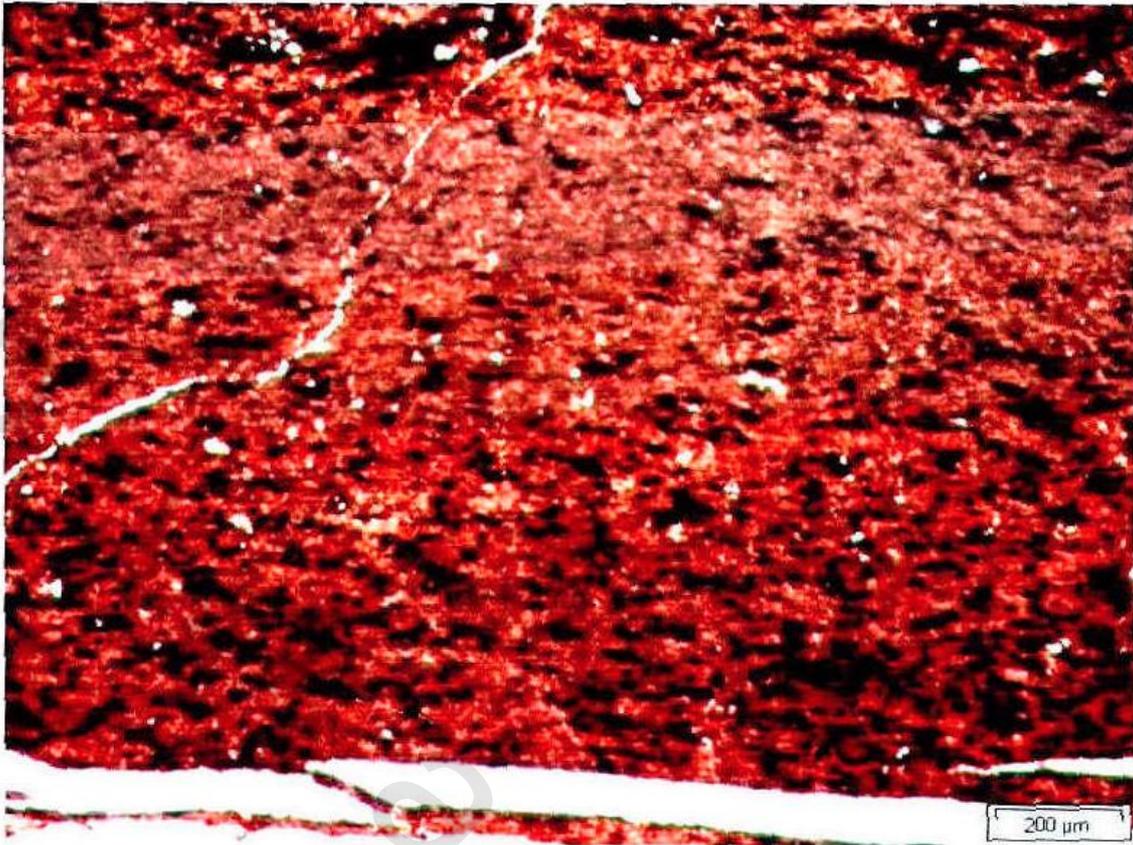


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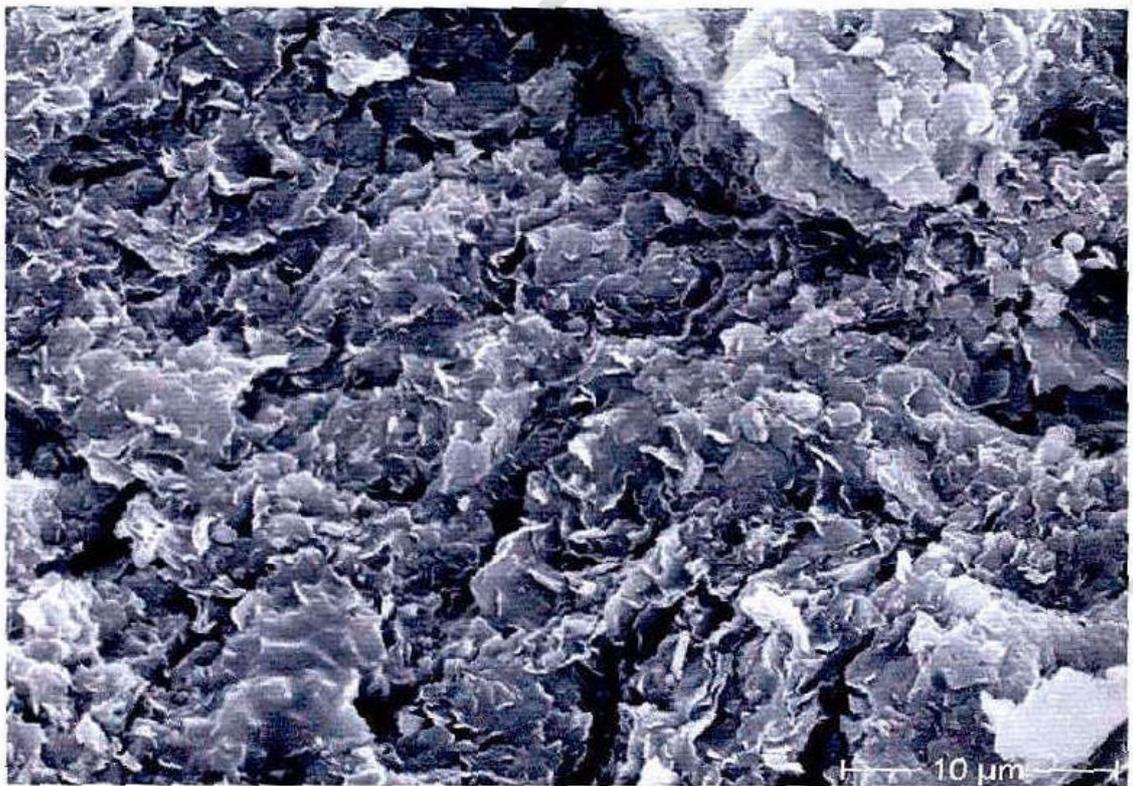


B

PLATE 3

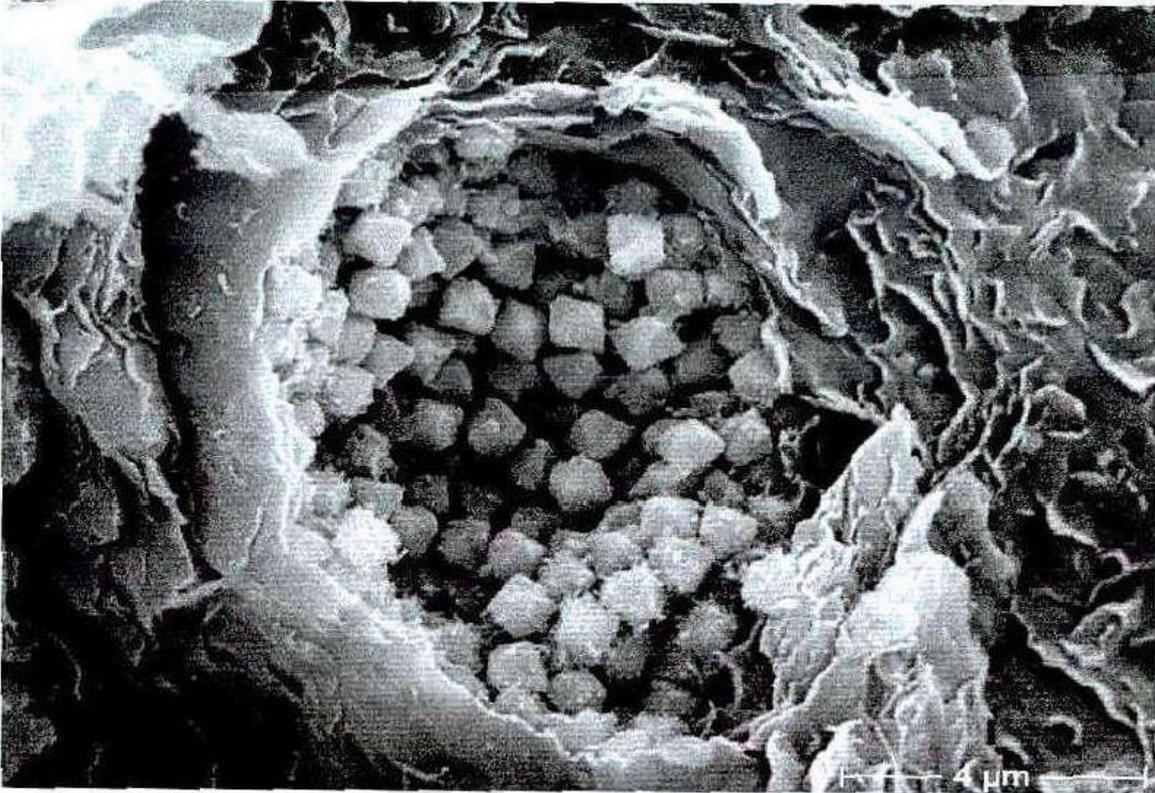


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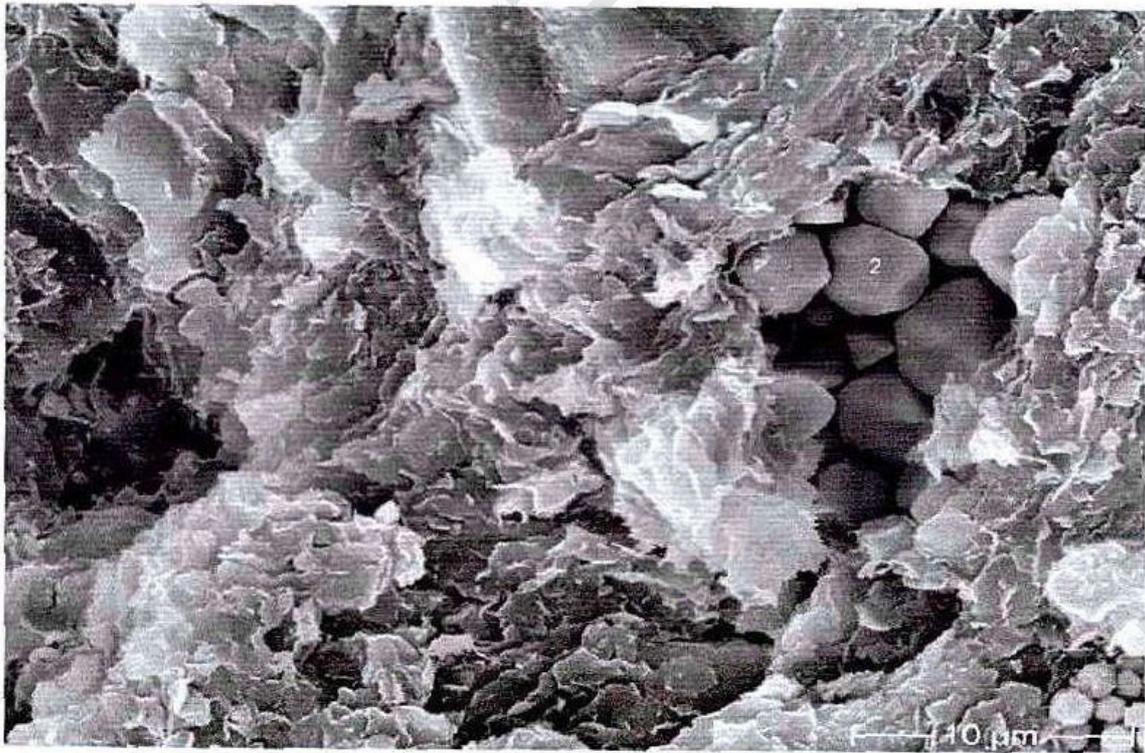


B

PLATE 4

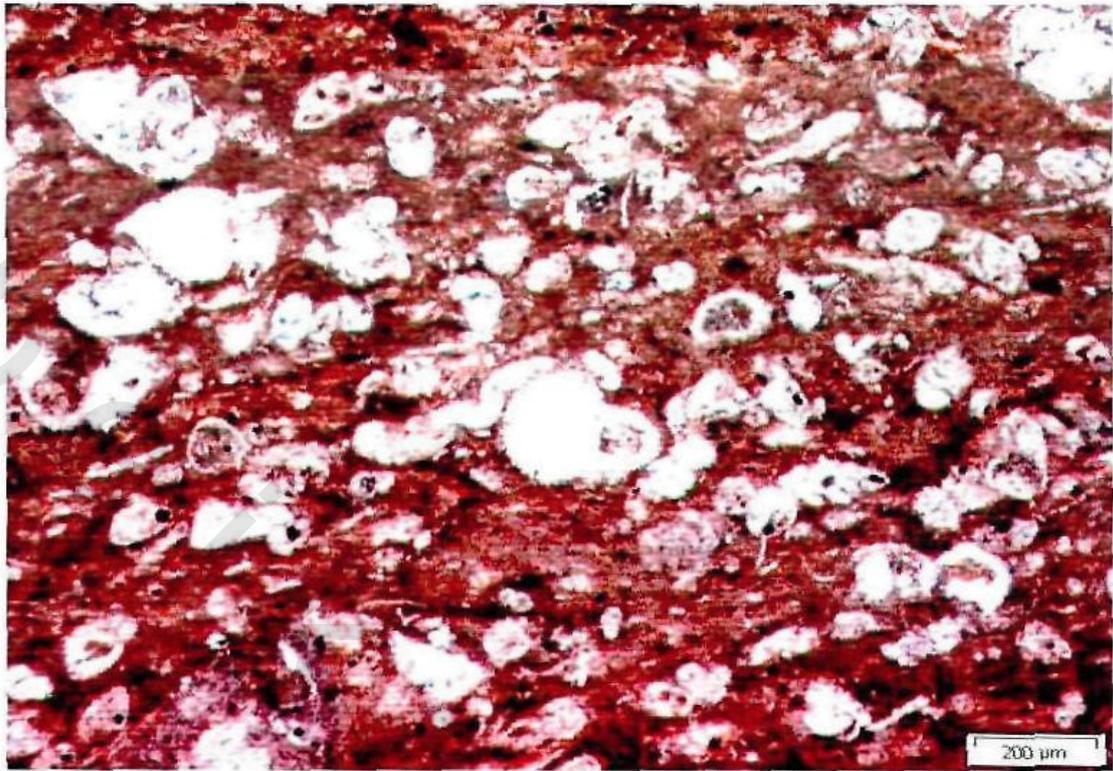


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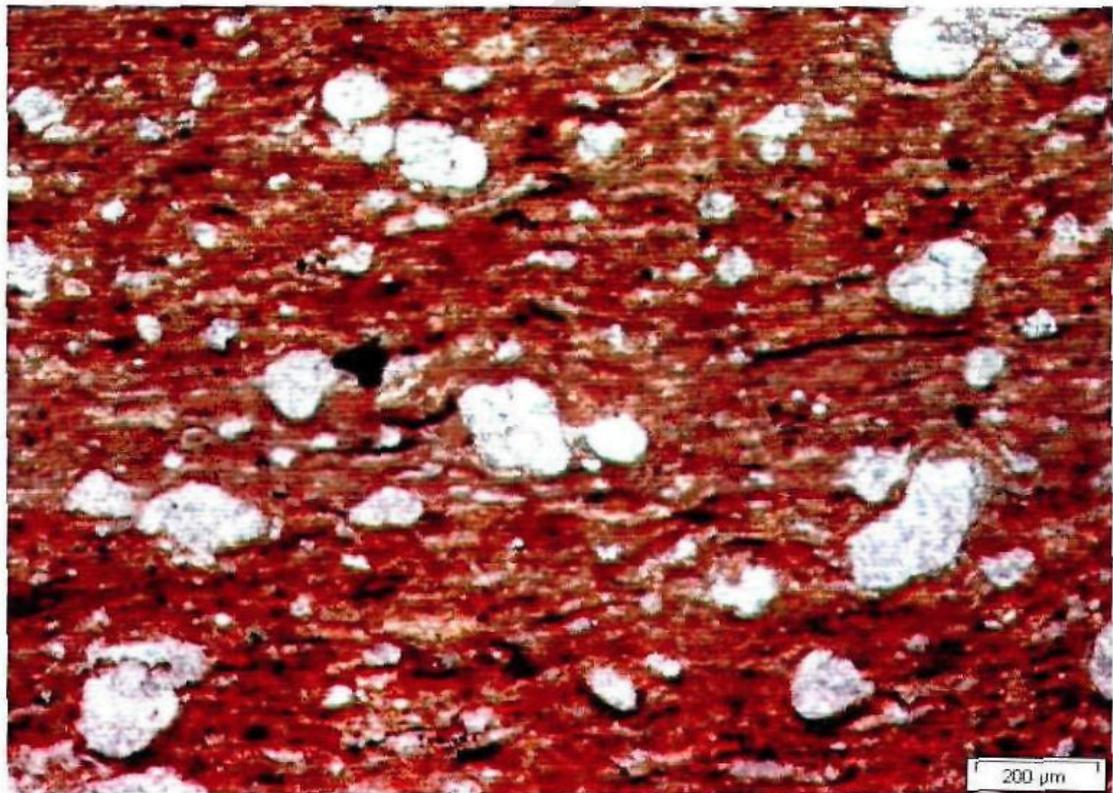


B

PLATE 5

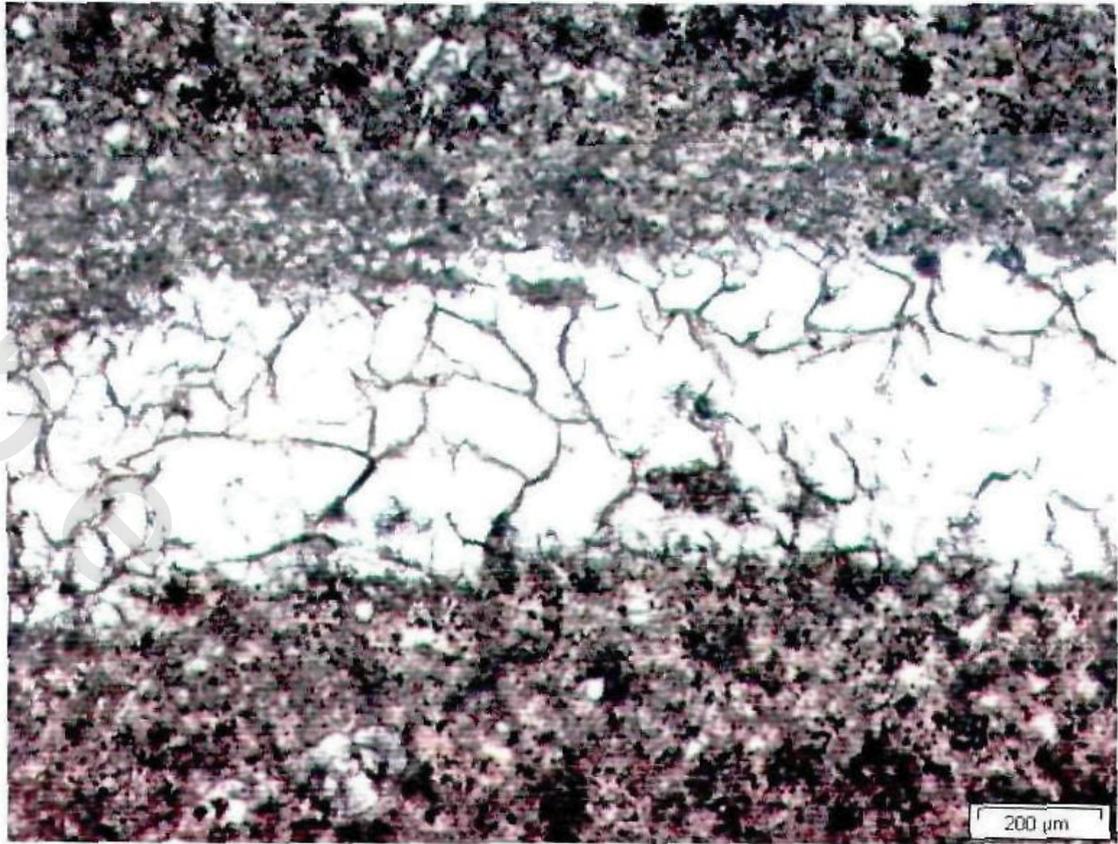


A

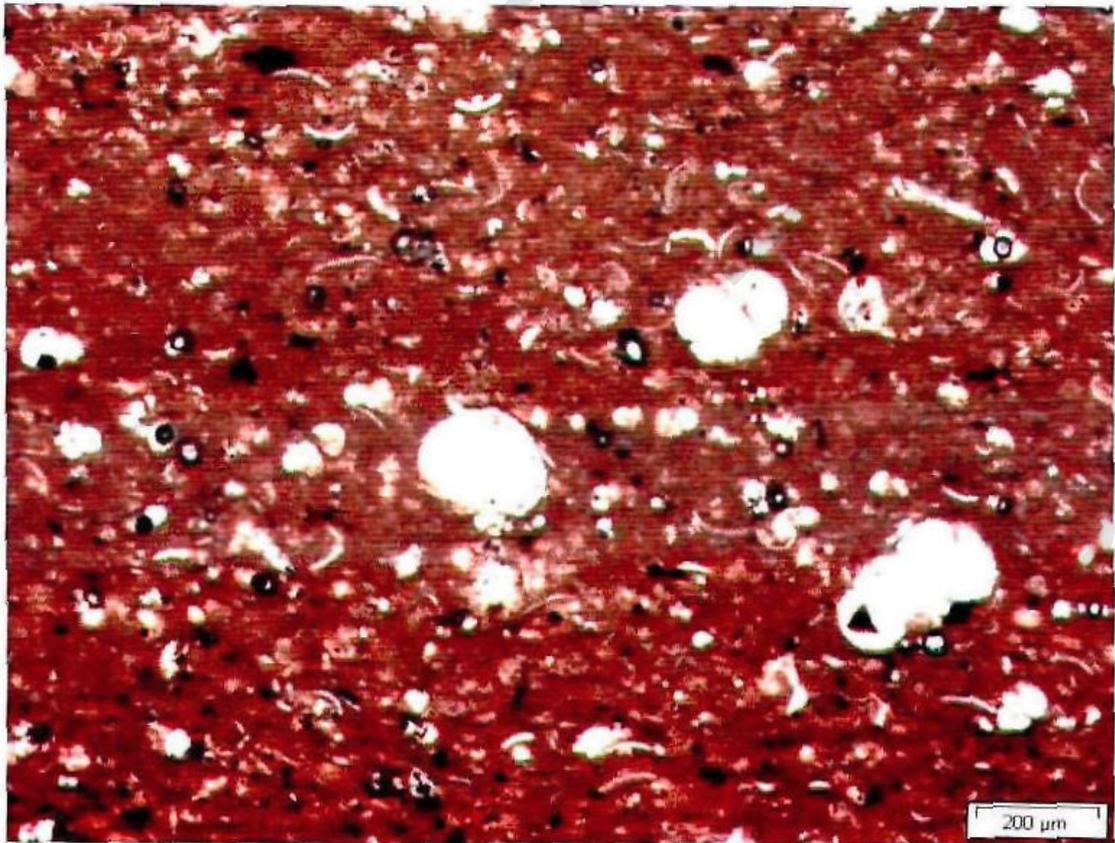


B

PLATE 6



A



B

PLATE 7



A



B

PLATE 7



c