

RELATIONSHIP BETWEEN THE URANIUM CONCENTRATION AND THE UPGRADING OF EL-SIBAEYA PHOSPHATE ORE BY NEW PHYSICAL PROCESSES.

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ABSTRACT

Phosphate plays a significant economic role in developing countries because the phosphate rock is consumed in the agricultural sector as fertilizers and animal feedstocks as well as used in the manufacture of high-grade phosphoric acid used in the manufacture used in pharmaceuticals, detergents, food products and other industrial uses. So, this research focus is represented in how to apply some new physical concentration processes derived from ore dressing to arise the concentration of P_2O_5 (21.14%) in sample of 10 Kg of low grade Egyptian phosphate ore was collected from East El-Sibaeya region as an alternative method to the existing calcination method, which is not friendly environment and has several disadvantages and accordingly the find relationship between the uranium concentration and the upgrading of El-Sibaeya phosphate ore. Upgrading the phosphate ore is done through crushing, screening, up current Classifiers, gravimetric separation and hydraulic separation. The results of this study led to achieve the desired product (high grade of phosphate) which is imperative to meeting market requirements, and at optimum conditions gave a product which analyzed P_2O_5 (33.63%), CaO (47.66%), MgO (0.57%), SiO_2 (4.91%), Na_2O (0.49%), K_2O (0.89%), Al_2O_3 (0.64%), Fe_2O_3 (1.25%) and U (172.12 ppm).

Keywords

Phosphate ore, crushing, screening, up current classifiers, gravimetric separation and hydraulic separation.

1. INTRODUCTION

Phosphate rock is the only commercially feasible source for the production of phosphorus fertilizers and elemental phosphorus. About 95% of the produced phosphates are consumed in the agricultural sector as fertilizers and animal feedstocks. The world annual phosphate production in 2012 is around 217 million tons, and the global reserves amount to 67 billion tons. Egypt has about 4% of the world phosphate reserve (2.78 billion tons) and produces about 3 percent of the world phosphate production (about 6 million t/y). Geologically, the economic phosphate beds belong to the central facial zone of the upper senonian age (upper Cretaceous and lower Eocene) deposits. Several studies suggest that phosphate rock reserves could be depleted within 50-100 years (Steen, 1998, Dehaes et al., 2009, Smil et al., 2009; Vaccari, 2009; Cordell, 2010) while others are more optimistic (Van kauwenbergh, 2010; Van Vaccariren et al, 2010). The distribution of reserves, which was already thought to be significantly concentrated wilt just five countries in control of 86% of global reserves (Jasinski 2010), was further intensified with the release of the IFDC report, and its subsequent revision to USGS estimates. The latest estimates, now suggest that few countries control the world phosphate reserves wilt morocco alone controls 74.6% of global reserves with 5.0 billion tones, china 5.5% with 3.7 billion tons and Algeria 3.3%

with 2.2 billion tons (Jasinski, 2011). The rest of the world share only 16.6% of the world phosphate reserves, which amounts to 11.1 billion tons. At east Sibaeya, the phosphate ore (figure 1) used to be crushed and attrition washed to remove the clayey fine fraction (about 10-12% by weight, assaying about 12-18% P_2O_5).

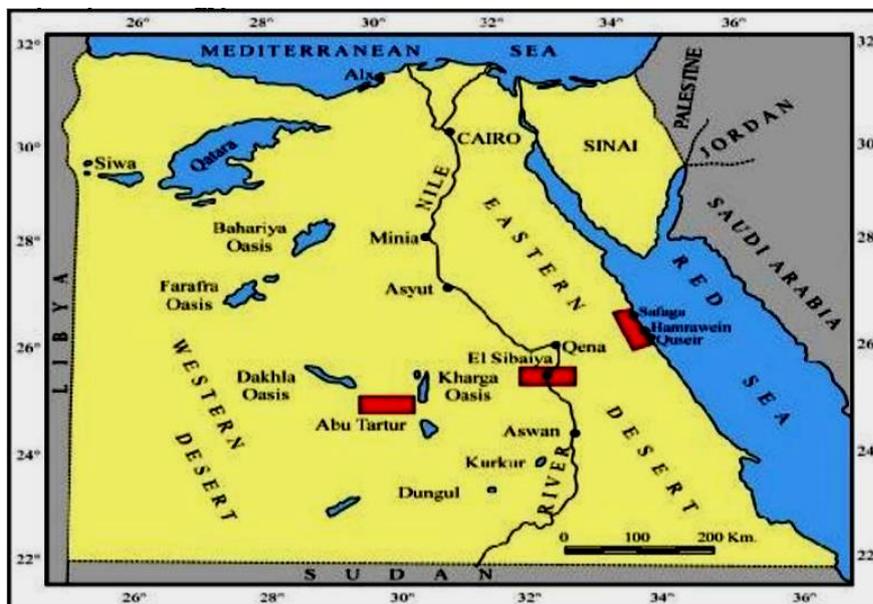


Fig. 1: Location map of the phosphate deposits in Egypt.

2. MATERIAL AND METHODS

2.1. Material

10 Kg of a low-grade Egyptian phosphate Sample from the east Sibaiya region was used for this Study. Chemical composition of the studied phosphate sample is determined by using XRD analysis.

2.2. Methods

Several beneficiation techniques for upgrading phosphate ore were applied in the present study.

2.2.1. Crushing and screening

This is the first step to dissociate the phosphate ore and liberate the minerals and other constituent ^[2,3,4,10]. The hammer mill used to crush the ore and then the product of the crusher flows on vibrating screen to separate the fraction, which is more than 100 mesh.

2.2.2. Up current classifiers

Up current classifiers is used for mechanically cleaning and removing all the Slimes (Kaolinite) and fine quartz from the sample which act on the differences in the size and density of mineral particles. ^(1,10,11) Just enough water was injected through perforated spray pipes and both the mechanical stirrer of 1 HP and stirring speed 200 rpm are adjustable (figure 2). Then the cleaned sample was dried and subjected to concentration by gravimetric separation and the tailing (slimes and low-density mineral grains) was filtered, dried, weight and bagged for analysis.

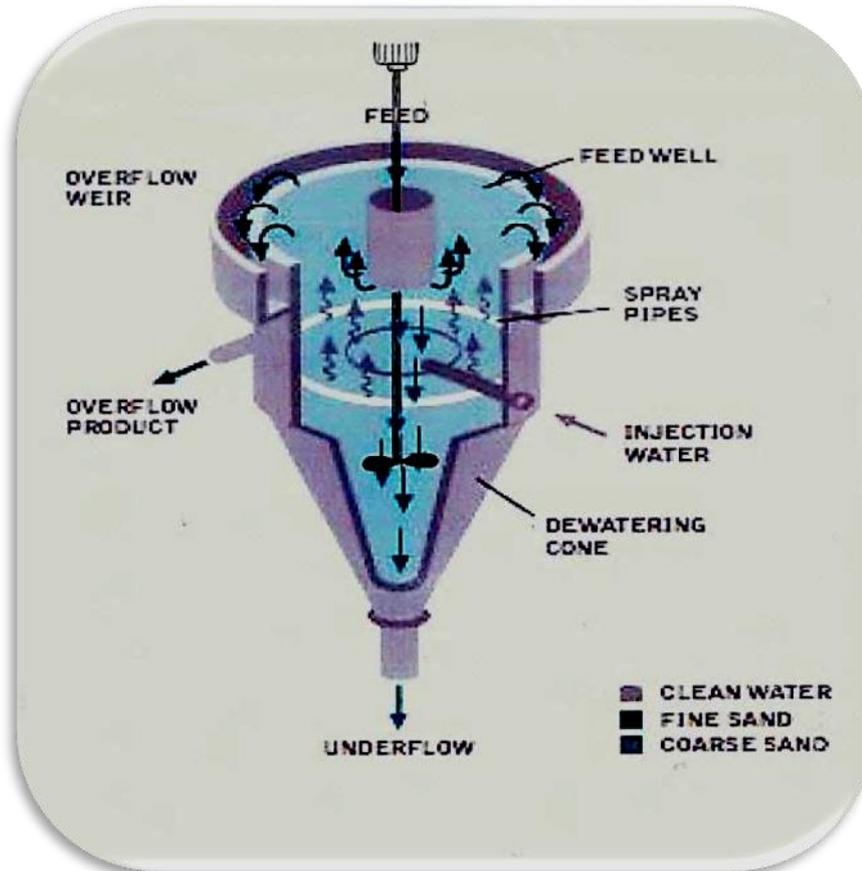


Fig. 2: Longitudinal section of up-current classifiers.

2.2.3. Gravimetric separation

The shaking table concentrator is used to concentrate P_2O_5 in the cleaned sample which coming from the previous step, which act on the difference of specific gravity between the important minerals and the gangue^(5,6,7,8,9,11). The separated materials were obtained under the optimum conditions, particle size was less than 150 mesh (100 μm), The optimal deck slope of the shaking table was 10, the optimal feed water flow rate was 8 liters per minute. The concentrate phosphate sample was dried, weighed and bagged for analysis.

2.2.4. Hydraulic separation

In this process we used the hydraulic classifier (designed by El-Shennawy, A. A.) to promote the concentration of P_2O_5 of the sample which coming from the previous step. The hydraulic classifier is used to separate the solid particles into two or more products according to their velocities when falling through a fluid medium. Generally, water is used as fluid medium. Velocities of particles depend on their size, shape and density. Particles with higher density and large size will settle down quickly as compared with particles with lower density and smaller size. The water injected through each of glass unit can be adjusted (figure 3a, b). As a result of using the hydraulic classifier, three grades of the concentrate phosphate sample were obtained as in the following flow sheet showing the separation steps for upgrading of El-Sibaeya phosphate ore as in figure 4.

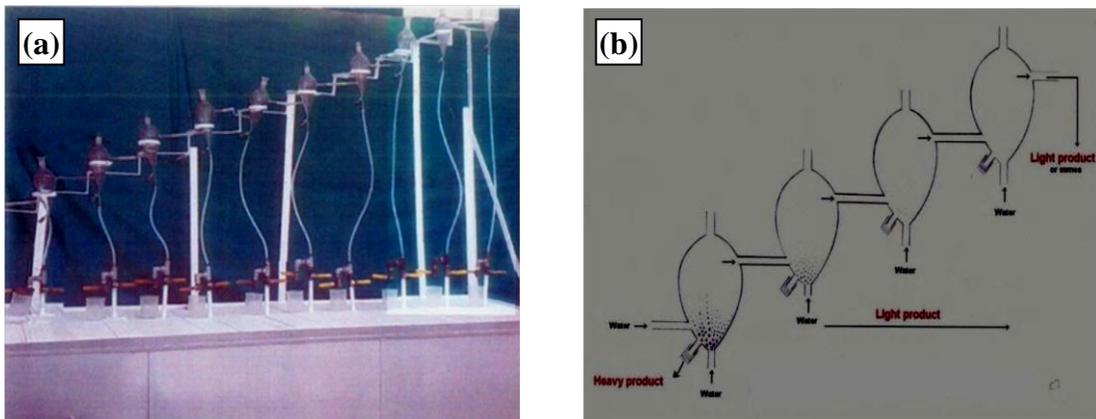


Fig. 3: (a) Hydraulic separation device, (b) Principle of hydraulic classifier.

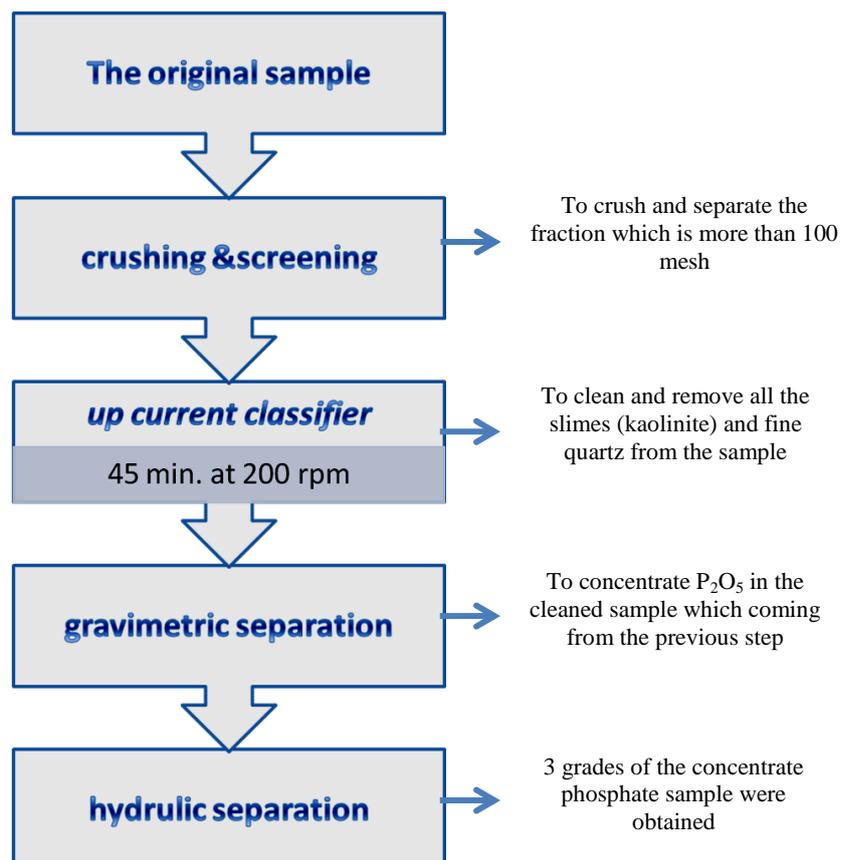


Fig. 4: A simplified flow sheet showing the separation steps for upgrading of El-Sibaeya phosphate ore.

3. RESULTS AND DISCUSSIONS

The sample was subjected to XRD analysis as shown in figure 5 before investigation of the physical processes to concentrate P_2O_5 in a sample of low-grade Egyptian phosphate ore was collected from East El-Sibaeya region. The XRD pattern of examined low grade phosphate sample indicates that, apatite ($Ca_{10}(PO_4,CO_3)_6(F,OH)_2$) is the predominant phosphate mineral, whereas calcite($CaCO_3$) is the main carbonate gangue mineral associating the ore with some dolomite $CaMg(CO_3)_2$ mineral. In addition, the sample was analyzed by means of XRF as shown in figure 6. It has shown that phosphate ore contains Si (19.48%), P (9.23%), Ca (60.97%), Mn (0.38%), Fe (8.81%), Zn (0.12%), and Sr (0.65%). In addition, the sample was analyzed for its major oxides and trace elements constituents before starting the upgrading experiments. The results of chemical analysis of the sample can be seen in table 1, which show that sample is not imperative to meeting market requirement.

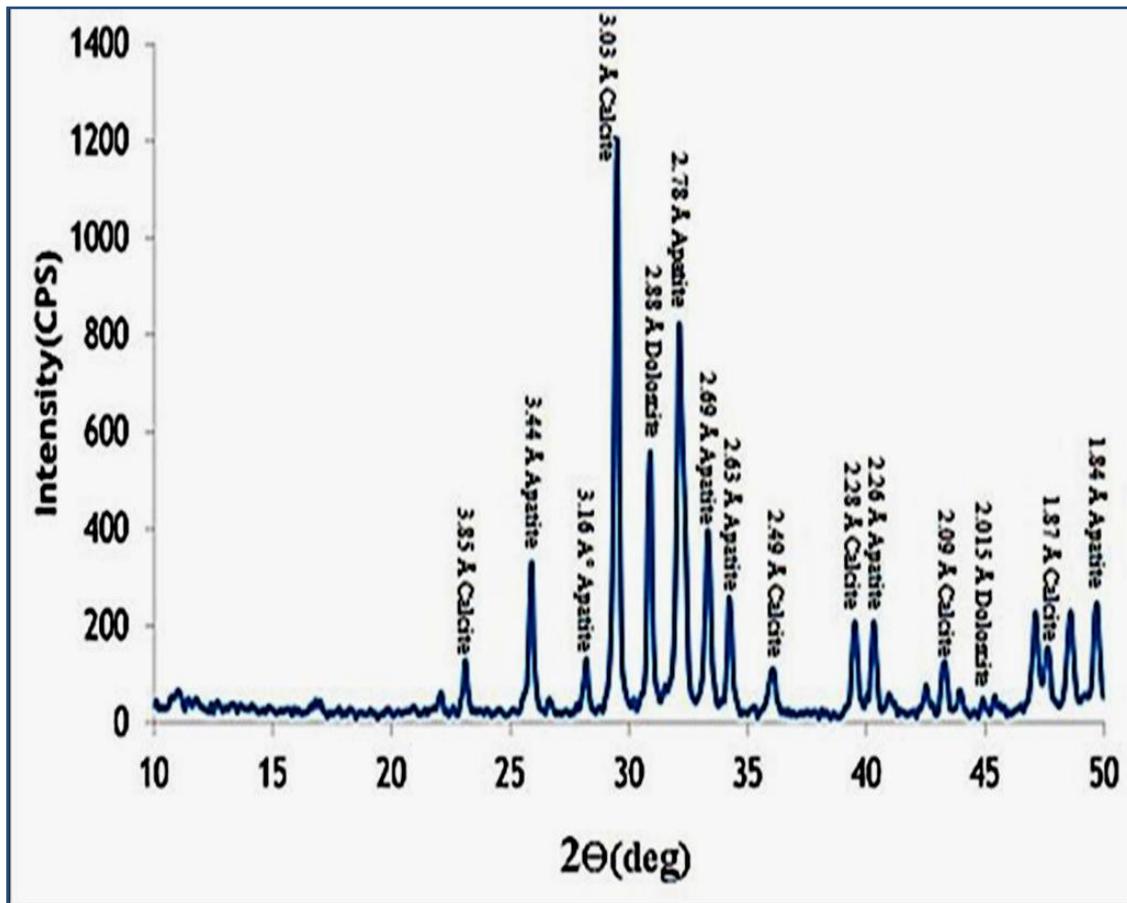


Fig. 5: XRD pattern of examined low-grade phosphate sample before beneficiation.

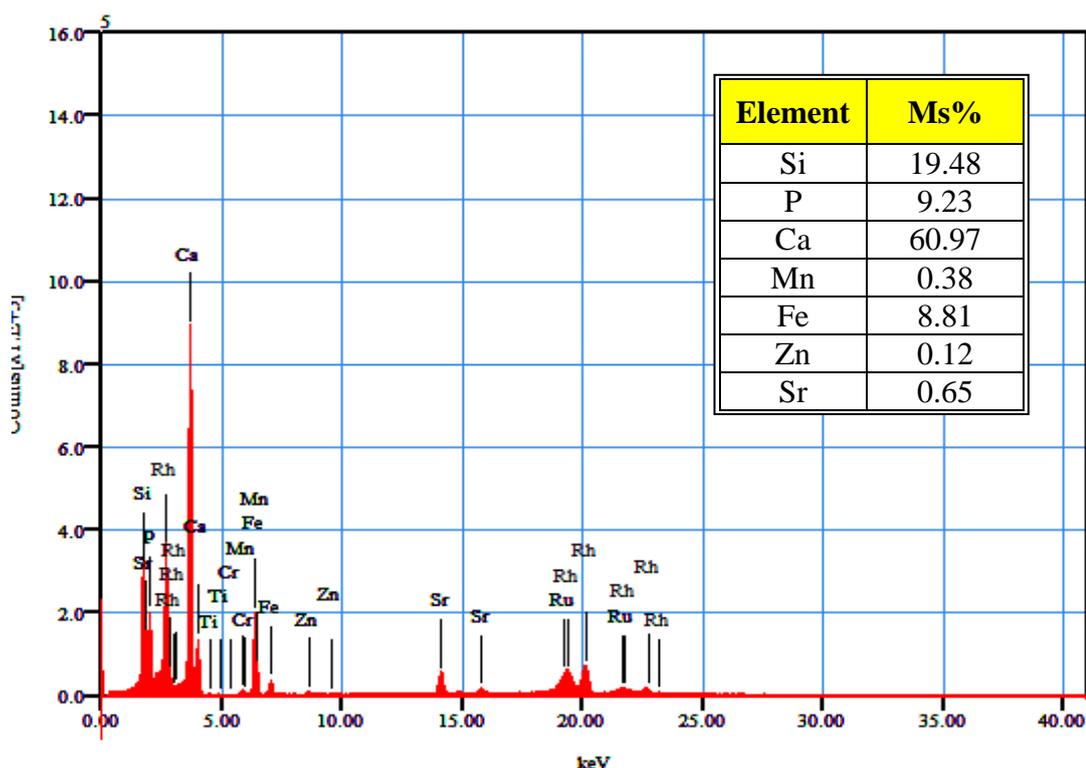


Fig. 6: XRF pattern of the original phosphate sample.

Table (1): Chemical composition of major oxides and trace elements of original sample.

Oxides	Content %	Trace elements	Content (ppm)
P ₂ O ₅	21.14	Cr	40.01
CaO	46.68	Co	2.96
MgO	3.04	Ni	8.04
SiO ₂	10.63	Cu	11.50
Na ₂ O	0.67	Zn	71.43
K ₂ O	0.42	Zr	31.07
Al ₂ O ₃	1.35	Rh	89
Fe ₂ O ₃	2.97	Y	205
MnO	0.03	Ba	13.93
Cl	0.45	V	96
F	1.27	Sr	353.07
SO ₄	2.11	Mn	822
L.O.I		U	39.99

Then, the phosphate sample was subjected to mechanically eliminating impurities by mean of up current classifiers. The cleaned sample was dried for analysis by XRF .The results are shown in figure 7. Moreover, it appears that the sample contains Si (15.33%), P (11.03%), Ca (56.46%), Ti (0.51%), Mn (0.35%), Fe (6.28%) and Sr (0.76%). In addition, the chemical analysis of major oxides and trace elements of the improved sample by up current classifiers was done and shown in table 2.

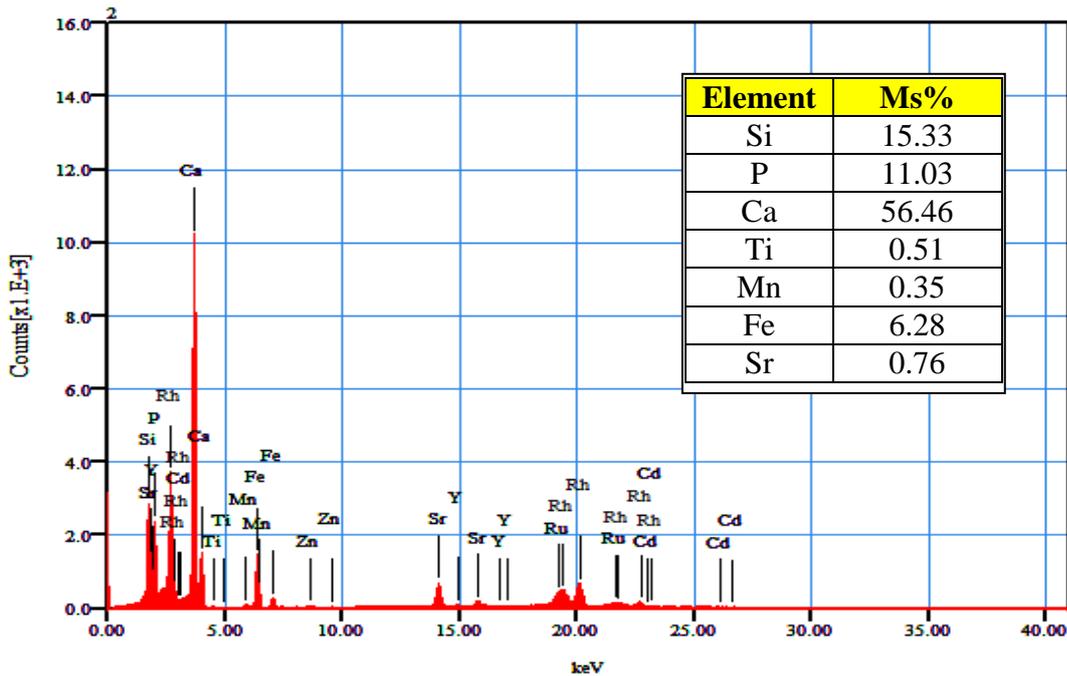


Fig. 7: XRF pattern of the collected sample from the up-current classifier.

Table (2): Chemical analysis of major oxides and trace elements of the improved sample by up current classifiers.

Oxides	P ₂ O ₅	CaO	MgO	SiO ₂	Na ₂ O	K ₂ O	SO ₄	Al ₂ O ₃	Fe ₂ O ₃	Cl	F	L.O.I
Content%	25.30	43.61	1.73	9.21	0.56	0.25	2.80	0.41	2.64	0.51	2.10	11.20

The phosphate sample was then concentrated by mean of shaking table using different inclination s and flow rates the best results were at flow rate 1.3 L/min and an inclination of 2 degree. the obtained results by XRF indicates that using the shaking table technique improves the P content from 11.03% to 12.81% and reduces the iron content from (6.28%) to (3.92%) as shown in figure 8. Also the chemical analysis of major oxides and trace elements of the improved sample by shaking table was don and shown in table 3.

Table (3): Chemical analysis of major oxides and trace elements of the improved Sample by shaking table.

Oxides	P ₂ O ₅	CaO	MgO	SiO ₂	Na ₂ O	K ₂ O	SO ₄	Al ₂ O ₃	Fe ₂ O ₃	Cl	F	L.O.I
Content%	29.33%	46.30	0.65	7.62	0.21	0.24	1.61	0.71	2.43	0.23	2	10.60

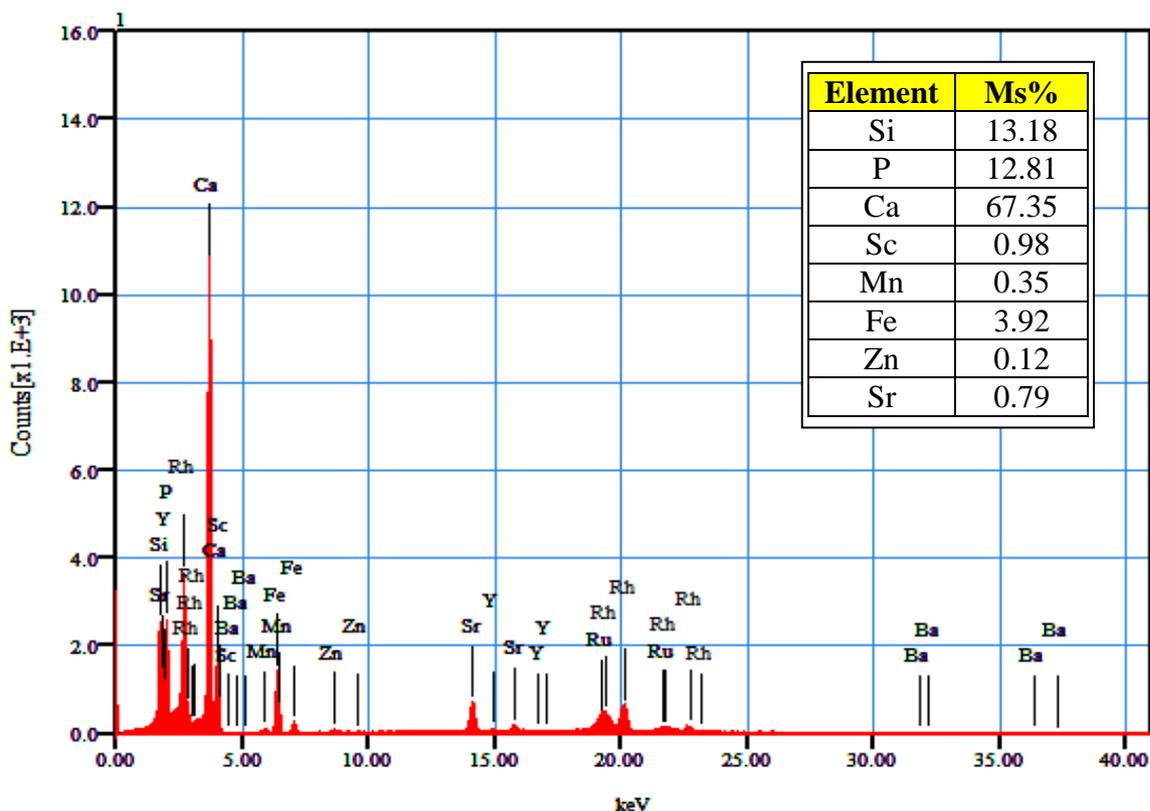


Fig. 8: XRF pattern of the separated sample from the shaking table.

Then the phosphate sample was followed by concentration by hydraulic separation which upgrading of phosphate sample requires partial removal of impurities and other elements that are detrimental to its end use. As a result of using hydraulic separation, three grades of phosphate separated (A, B, C) and the obtained results by X R F indicates that using the hydraulic separation technique improves P content from 12.81% to 13.50% in (grade c), to 13.75% in (grad B) and to 14.68% in (grade A) as shown in figures 9, 10 and 11. In addition, the chemical analysis of major oxides and trace elements of the improved samples by hydraulic separation was done and shown in tables 4, 5 and 6. Finally, the results of this study led to achieve the desired product (high grade of phosphate) which is imperative to meeting market requirements and to prove the relationship between the uranium concentration and the upgrading of El Sibaea phosphate ore by physical processes, which indicate that high-grade ore have highly concentration of uranium than low-grade ore. The collected high-grade phosphate, which obtained from the hydraulic separation, contains concentrated uranium (172.12 ppm) that could be directed to leaching and extraction of uranium.

Table (4): Chemical analysis of major oxides and trace elements of concentrate (C).

Oxides	P ₂ O ₅	CaO	MgO	SiO ₂	Na ₂ O	K ₂ O	SO ₄	Al ₂ O ₃	FeO ₃	Cl	F	L.O.I
Content%	30.92	45.90	0.73	6.81	0.10	0.64	1.68	0.64	2.38	0.03	3.27	8.21

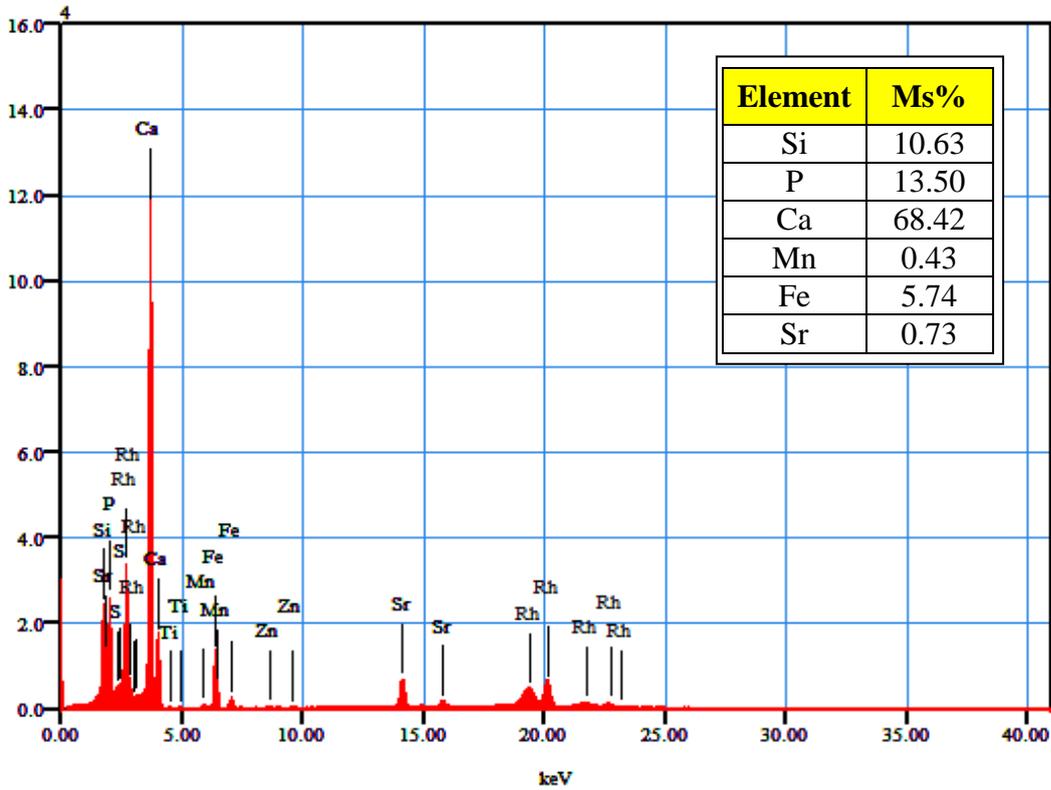


Fig. 9: XRF pattern of concentrate (C) from the hydraulic separation.

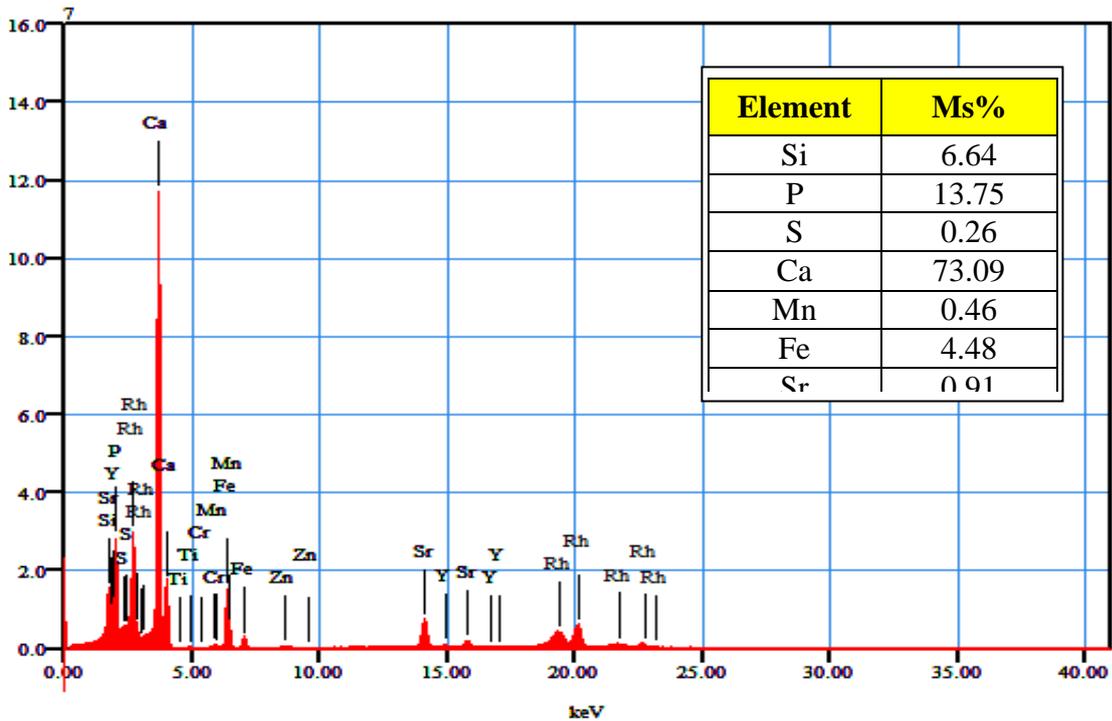
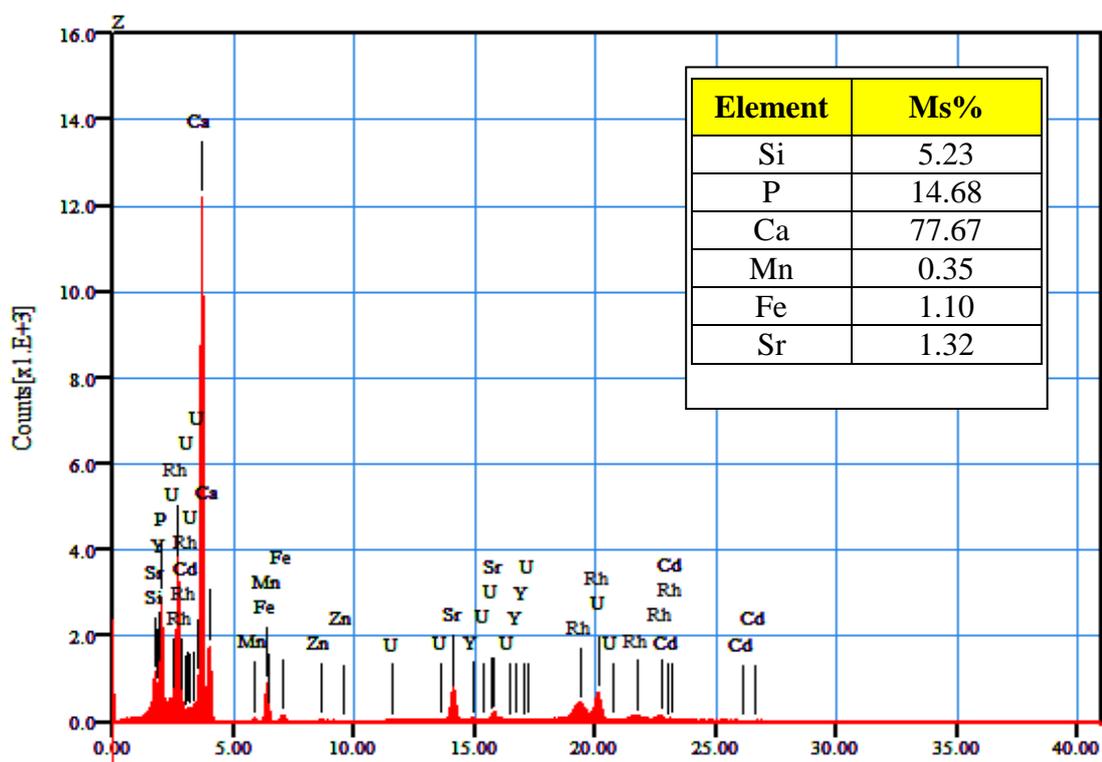


Fig. 10: XRF pattern of concentrate (B) from the hydraulic separation.

Table (5): Chemical analysis of major oxides and trace elements of concentrate (B).

Oxides	P ₂ O ₅	CaO	MgO	SiO ₂	Na ₂ O	K ₂ O	SO ₄	Al ₂ O ₃	FeO ₃	Cl	F	L.O.I
Content%	31.49	47.33	0.68	6.17	0.16	0.34	1.62	0.79	2.11	0.01	2.18	8.67

**Fig. 11: XRF pattern of concentrate (A) from the hydraulic separation.****Table (6): Chemical analysis of major oxides and trace elements of concentrate (A).**

Oxides	Content%	Trace elements	Content (PPM)
P ₂ O ₅	33.63	Cr	36
CaO	47.66	Co	9
SiO ₂	4.91	Ni	6.93
Fe ₂ O ₃	1.25	Cu	8.74
Al ₂ O ₃	0.64	Zn	66.34
MgO	0.57	Zr	28.76
Na ₂ O	0.49	Rh	103.01
K ₂ O	0.89	Y	149.31
F	1.89	Sr	342.09
Cl	1.74	Mn	744.19
SO ₄	1.07	U	172.12
L.O.I	9.27		

Table (7): The products that have been attained from low-grade Egyptian phosphate ore.

Product	Quantity	Percentage
Slime	2948.35 gr	29%
P ₂ O ₅ (33.63%)	3275.37 gr	33%
P ₂ O ₅ (31.49%)	1262.66 gr	31%
P ₂ O ₅ (30.92%)	908.62 gr	9%
Loss	693 gr	7%
Tailing	912 gr	9%

4. CONCLUSION

The present work is mainly concerned with the improvement of low-grade Egyptian phosphate ore (21.14% P₂O₅) from East Sibaeya area. Upgrading the phosphate rock is done through crushing, Screening, Up-current classifiers, gravimetric separation and hydraulic separation. The results of this work led to achieve the desired product (high-grade of phosphate), which is imperative to market requirements and to prove the relationship between the uranium concentration and the upgrading of El-Sibaeya phosphate ore by physical processes which indicate that high-grade ore have highly concentration of uranium than low-grade ore. At optimum conditions gave a product, which analyzed P₂O₅ (33.63%), CaO (47.66%), SiO₂ (4.91%), Fe₂O₃ (1.25%), Al₂O₃ (0.64%), MgO (0.57%), Na₂O (0.49%), K₂O (0.89%), F (1.89%), Cl (1.74%), SO₄ (1.07%) and U (172.12 ppm).

5. REFERENCES

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الملخص العربي

يعتبر الفوسفات أحد الخامات الهامة في مصر نظراً لكثرة استخداماته في العديد من الصناعات الهامة مثل إنتاج حمض الفوسفوريك وإنتاج المركبات الفوسفاتية الكيميائية. هذا بالإضافة إلى إمكانية تركيز واستخلاص العناصر الأرضية النادرة والمشعة. لذلك عمل هذا البحث على كيفية تطبيق طرق جديدة من التركيز الفيزيائي لرفع درجة تركيز ورتبة خامس أكسيد الفوسفور في خامة مقدارها 10 كجم من فوسفات شرق السباعية (P_2O_5 21.14%) وبالتالي رفع قيمتها الاقتصادية كذلك عمل هذا البحث على إيجاد العلاقة بين تركيز اليورانيوم ورفع درجة تركيز P_2O_5 في خامة فوسفات شرق السباعية بواسطة استخدام طرق جديدة من التركيز الفيزيائي ونتيجة لاستخدام هذه الطرق الفيزيائية والمتمثلة في استخدام كل من ماكينة الطحن التي تعمل بنظام الشواكيش وجهاز التعويم والفصل التناقلي والفصل المائي أمكن رفع درجة تركيز P_2O_5 في خامة فوسفات شرق السباعية من 21.14% إلى 33.63% ورفع درجة تركيز U من 39.99 ppm إلى 172.12 ppm وهذا ما أكد على أن هناك علاقة طردية بين رفع درجة تركيز P_2O_5 ودرجة تركيز U في خامة فوسفات شرق السباعية.