Mineralogical and Chemical Characteristics of Phosphates from the Djebel Onk Deposits (Tebessa, Algeria)

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Abstract

Algeria has important phosphate reserves (2 billion tons) located in the east of the country at Djebel Onk. This mining district is located in the northwestern part of the Algerian Sahara near the Algerian-Tunisian border. The granulo-chemical and XRD analytical results confirm the phosphate depletion of Bled El Hadba layer and their enrichment in carbonate and dolomite, in comparison with the layer of Kef Essennoun. Phosphorite particles are heterogeneously grained. Although the two deposits are relatively close to each other, they show different mineralogical and chemical characteristics, which may cause the use of different mining exploitation methods.

Keywords: *phosphates, particle size, chemistry, petrography, Algeria*

1. Introduction

Algeria has rich mineral resources such as hydrocarbons, clays, and phosphate. Phosphate is mined in the region of Djebel Onk, which is located in the Tebessa region, and which contains more than two billion tons of phosphorite reserves distributed across different deposits [1]

Dejbel Onk mining district belongs to the Gafsa-Metlaoui-Onk basin, and phosphorite mineralization is found in five sectors: Kef Essennoun, Djemi Djema, Bled El Hadba, Djebel Onk North and Oued Betita [2-3].Phosphates are of great importance because of their applications in several sectors, particularly in the fertilizer and phosphoric acid industries. However, this sector imposes quality requirements on these phosphates concentrates [4-5] which consists in eliminating harmful impurities; such as, clays, silica, gypsum, etc. [6-7]. On the other hand, the deposits suffer from extensive resource exploitation by the SOMIPHOS group mining company, which causes environmental pollution. Another challenge is to recognize new economic sources in phosphorites, such as Rare Earth Elements (REE) [8-11].

Kef Essennoun deposit is characterized by a thick (~35 m) layer of Upper Thanetian phosphorites, divided into three sub-layers according to their P_2O_5 and MgO contents. The Bled El Hadba deposit is characterized by a ~30 m thick phosphorite layer [12] that occasionally contains marly phosphate intercalations with a marked drop in P_2O_5 contents [13].

This study aims to use several physicochemical methods to assess the mineralogical and chemical characteristics as well as the grain-size of the main minerals in each type of ores. Comparison of these characteristics will verify whether the enrichment procedures applied to beige minerals (Bled El Hadba) and (Kef Essennoun) are compatible with the common mineral processing method. Thus, the main objective of this research is to study the granulometry, mineralogy and chemical properties of the phosphate facies of the Kef Essennoun and Bled El Hadba deposits.

2. Geological Setting

The phosphate deposits near to Bir El Ater (Figure 1) are located in the transition between the eastern part of the Saharan Atlas to the north and the Sahara Platform to the south. The boundary between these two tectonic units is marked by the fault or flexure of the southernmost Atlas. The Atlas Mountains belong to the Alpine belt which was formed by the convergence of the Eurasian and African plates during the Miocene period [14].

The stratiform marine phosphate deposits are largely developed on the Algerian northeastern territory. These Tertiary phosphate fields (late Paleocene – early Eocene) belong to the large Mediterranean Phosphogenic Province which extends from Morocco to the Middle East (Iraq, Jordan, Syria etc.). The phosphate rocks of this province are predominantly of Cretaceous – Eocene ages [15-19].

The Algerian layers are from the lower Tertiary, mostly upper Thanetian, occasionally upper Thanetian - lower Ypresian Chouabine Formation, with a total thickness of 68 m. The main phosphate layer locally reaches a maximum thickness of 43 m. It is characterized by grains of phosphate pseudo--oolites and coprolites, and locally by a significant amount of fish teeth and fragments of phosphatic bones. The base of the Chouabine Formation is composed of lower Thanetian bituminous laminated marls, with irregular limestone intercalations containing a typical gastropod fauna.
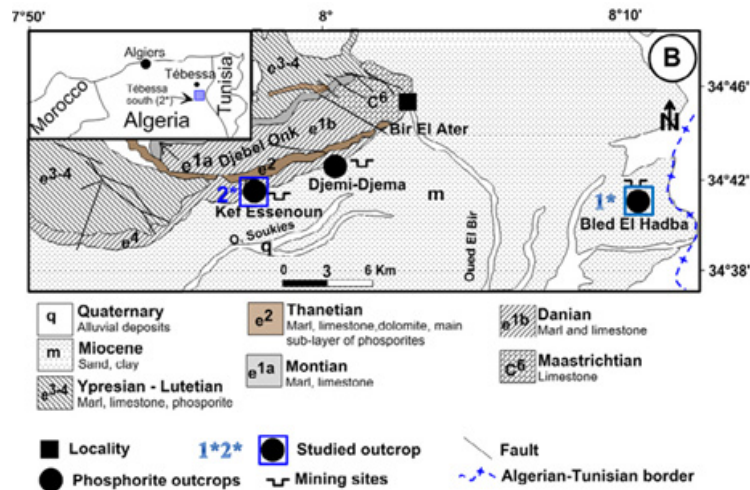
Fig. 1. Simplified geological sketch map of Djebel Onk region [22]
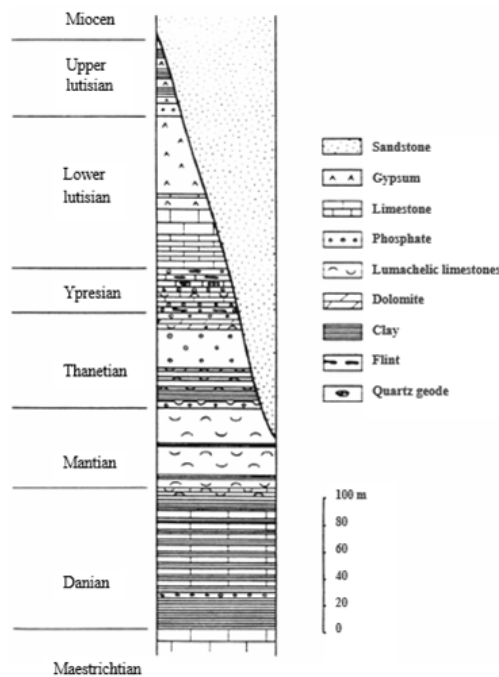Rys. 1. Uproszczona mapa geologiczna regionu Djebel Onk [22]

Fig. 2. Stratigraphic column of Jebel Onk [23]
Rys. 2. Kolumna stratygraficzna Jebel Onk [23]

The economically significant phosphorite layers at Djebel Onk (Tebessa) are in close spatial and chronological relation and share affinities with the layers known in Tunisia [20]. Many localities with phosphorite deposits, however, exhibit some differences in terms of petrography, geochemistry, and depositional environments [1]. Those located to the north of Tebessa (Djebel Dyr and El Kouif) are the equivalent of Ain Kerma, Kelaât Djerda and Sra Ouartane from Tunisia; they exhibit similar dimensions.

Those located south of Tebessa, such as Djebel Onk and the western side of Djebel Zrega, show considerable economic potential and are the equivalent of the Tunisian deposits in the Basin of Gafsa, such as the deposits of M'rata, Redeyef, Kef Eschfair and Metlaoui. The upper part of the phosphatic layer is represented by the YpresianMetlaoui Formation with a general thickness of 50 to 55 m. It is characterized by the presence of lumachelic limestones and marls with abundant flint concretion [21].

This large phosphate basin, located between Algeria and Tunisia (Figure 1), is also known as the Gafsa-Bir El Ater Basin. The Bled El Hadba (BEH) and Kef Essennoun (KES) deposits are located in this basin and represent the objective of this study (see Figure 2). The prospected area consists mainly of upper Cretaceous to lower Eocene marine sediments that are covered discordantly by thick continental sandy and argillaceous Miocene to Quaternary deposits.

3. Sampling and Methodology

Samples for petrographic and chemical analyses were taken from the outcrops of the three main phosphate sub-layers in both Kef Essenoun (KES) and Bled El Hadba (BEH), according to the structure of the deposits (top, main, and basal).

Six samples were taken (one for each sublayer), systematic from bottom to top in order to follow vertical evolution and determine the different types of facies for petrographic analy-

Fig. 3. Contact between the black and beige phosphates and the upper phosphatic dolomite of the Kef Essennoun (KES) deposit. A: Black phosphate; B: beige phosphate; C: Phosphatic dolomite

Rys. 3. Kontakt czarnych i beżowych fosforanów z górnym dolomitem fosforanowym złoża Kef Essennoun (KES). Odp.: czarny fosforan; B: beżowy fosforan; C: Dolomit fosforanowy
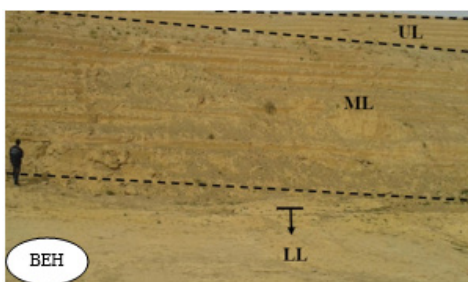

Fig. 4. Contact between the three sub-layers at the BEH deposit. UL: upper sub-layer; ML: main sub-layer; LL: lower sub-layer

Rys. 4. Kontakt trzech podwarstw na złożu BEH. UL: górna podwarstwa; ML: główna podwarstwa; LL: dolna warstwa podrzędna
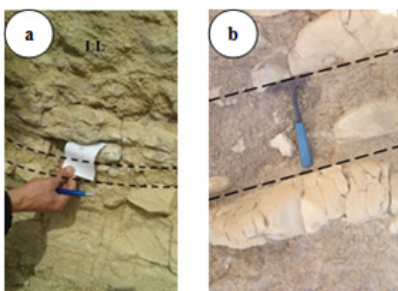

Fig. 5. Lower Thanetian phosphate layers (a): Bled-El Hadba and (b): Kef Essennoun

Rys. 5. Warstwy fosforanowe dolnego tanetu (a): Bled-El Hadba i (b): Kef Essennoun

ses. Thin sections were prepared from the six samples. The petrographic study was carried out using an optical microscope at the Department of Geology, University Annaba.

Two samples (one for each deposit) were taken in trenches (one trenches for each sublayer), mechanical preparation for these samples consisted of homogenization, crushing (≤ 4 mm), quartering, dry sieving (4 to 0.05 mm), grinding (<90 μm), and sieving through a series of dry sieve screens. Each grain size fraction was powdered (<90% passing through the 80 μm sieve) for chemical analyses provided to us by the Iron and Phosphate Exploitation Company (FERPHOS).

The dimensional classification (used to determine the weight distribution of particles of a material according to their dimensions) of the raw ore obtained after mechanical processing was carried out by the dry sieving method using a vibrating sieve on a series of sieves with openings ranging ≤ 2 mm. The different particle size fractions obtained after separation by sieving was grinded down to ≤ 100 μm, to facilitate chemical reaction during subsequent treatments. Based on previous studies [24-25] on this type of ore, we limited the duration of sieving to 10 to 15 minutes to avoid significant errors due to the crushing effect (attrition).

The X-ray diffraction was carried out with a powder X'Pert Pro Panalytical diffractometer using the copper line in the Laboratory of Material Technologies and Process Engineering (LTMGP) at the University of Bejaia. The determination of the major elements was carried out in the FERPHOS laboratory using the phosphomolybdate spectrophotometry, atomic absorption spectrometry (AAS) and calcimetry methods.

4. Results and Discussion
4.1 Petrographic data

The deposits of Djbel Onk (BEH and KES) are brittle phosphorites and are, therefore, classified as phospharenites [12-26]. The phosphatic facies is represented by homogenous fine grains (200 μm to 300 μm), rarely heterogeneous coarse-grained (up to 3 mm) phosphorites. Phosphatic particles are composed mainly of pellets, coprolites, bioclasts (mainly bone and fish teeth fragments), and glauconite. The rocks of the Kef Essennoun deposit are beige to brown in color at the top and dark grey to black at the bottom of the layer (Figure 3). Color variations are most likely related to organic matter contents [27].

Based on macroscopic, microscopic, and chemical studies we distinguish three phosphate sub-layers from the bot-
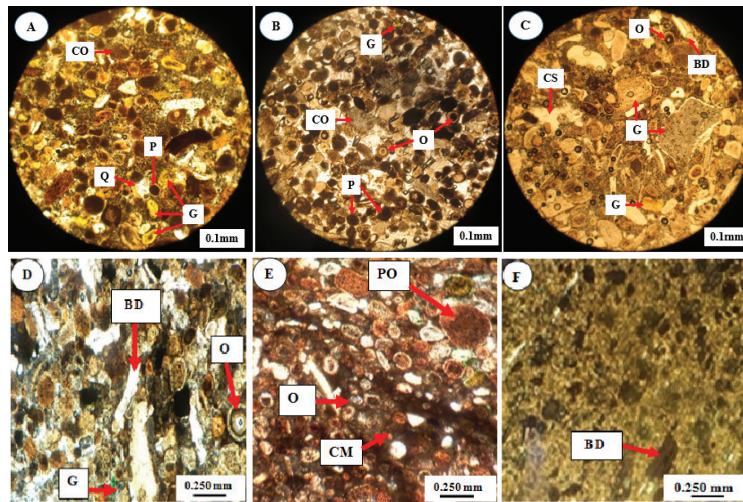
Fig. 6. Microscopic images of polished thin sections of Bled El Hadba (A, B and C) and Kef Essennoun (D, E and F) phosphates ores. BD: Bone Debris; PS: Pseudo-oolites; CM: Micritic Cement; G: Glauconite; O: Oolite; CO: Coprolites; P: Pellet; CS: Sparitic Cement; Q: Quartz

Rys. 6. Obrazy mikroskopowe wypolerowanych cienkich przekrojów rud fosforanowych Bled El Hadba (A, B i C) i Kef Essennoun (D, E i F). BD: szczątki kości; PS: Pseudo-oolici; CM: cement mikrytyczny; G: glaukonit; O: Oolit; CO: koprolity; P: Pellet; CS: cement sparytowy; P: Kwarc

tom to the top of the phosphorite layer in the BEH deposit (Figure 4):

Lower sub-layer (LL): The thickness is variable between 2.4 and 18 m, characterized by fine to medium-grained phosphorites with calcareous-dolomitic cement with rare limestone intercalations.

Middle sub-layer (ML): This section is thicker, reaching 29.75 m, which increases towards the western part of the basin. The beige, rarely dark-gray phosphates are fine-grained with clayey-marly matrix, occasionally sandy, soft and brittle. This section contains intercalations of phosphatic limestones with calcareous-dolomitic cement.

Upper sub-layer (UL): The thickness varies from 2.3 to 18 m. This layer disappears gradually towards the northwestern part of the section, near the studied area. The lithology is similar to that of the lower layer; it consists of beige, dark-gray, fine to medium-grained hard and compact phosphorites, with calcareous-dolomitic cement. Several quartz geode intercalations are occasionally observed.

The macroscopic observations of the outcrops allowed the determination of the following lithologies:

The Danian is composed of a thick layer of marls and whitish limestone that are overlain by intercalations of oyster limestones of Montian age surmounted by a medium phosphate bed rich in fish debris of Thanetian age (Figure 5). This is overlain by limestones with clays and marls, and black gypsum-rich marls.

The upper Thanetian is represented by a thick layer of phosphates (Figure 5 b).

The top of this phosphate layer consists of lower Ypresian phosphatic dolomites and phosphatic shark teeth-enriched (Elasmobranchii and cartilaginous fish) limestone, with intercalations of whitish limestones and flint. The teeth are represented by lateral-central and Hypotodusverticalis (superior side teeth). The change of lithology indicates a regressive tendency during the sedimentation of the deposits. This was followed by a reopening of the marine field during the late Ypresian represented by limestones and dolomites with flint.

Early Lutetian consists of dolomites and limestones with intercalations of quartz geodes. During the sedimentation of the upper Lutetian green clays, followed by limestones, marls and gypsum, the depth of the basin got significantly lower.

The uppermost beige phosphate of BEH (UL) is hard, coarse-grained and colored in its lower part by iron hydroxides. It contains shark teeth and bones, and bivalves can be observed in its lower part.

The middle phosphates of BEH, of brown color (ML), are fine-grained and friable.

The lowermost phosphates of BEH, of beige color (LL) are hard and contain white marl intercalations with a thickness up to 20 cm (Figure 5 a). The base of the bed is delimited by the presence of dark brown marls.

The phosphates of KES are represented by three types of facies: upper Thanetian black (A) and beige (B) phosphates, and lower Ypresian phosphatic dolomites (C).

The BHS deposit is poorer in P2O5 and richer in MgO contents than that of KES. Moreover, the natural size of apatite is finer than the material from KES. It is difficult to carry out a transfer of the data and parameters of the processes of treatment between these two deposits.

Petrographic examinations show that the phosphates of BHS (Figure 6) consist of pellets (50 µm to 100 µm), coprolites (0.5 to 1.6 mm), bone debris with varying shapes and sizes, oolites, quartz and glauconite (0.12 to 0.6 mm) that are cemented by carbonate, sparite (calcitic) or micrite (dolomitic). The cement of BHS deposits is generally dolomitic and calcitic but sometimes soft and not poorly-cemented [24].

The phosphates from the lower and upper part are characterized by an abundance of dolomitic and calcitic cement (75%) with the presence of a few heterogeneous grains: large-sized coprolites, bone debris, pseudo-oolites, glauconite, pellets and quartz of small grains (A, C). On the other hand, the phosphates of the intermediate sub-layer generally consist of fairly homogeneous grains: oolites, pseudo-oolites and pellets, with the presence of some small coprolites, bone debris, glauconite, and large quartz grains. These grains are bound by micritic cement (15%) of argillaceous nature however; the cement is also calcareous (B).
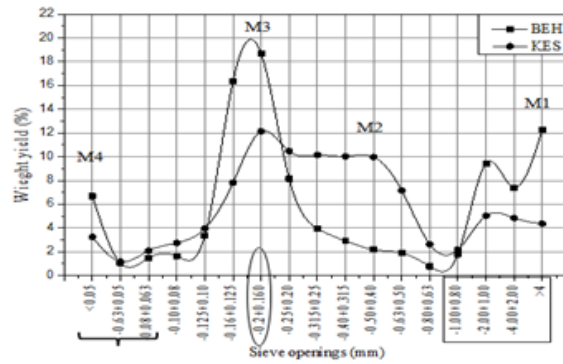
Fig. 7. Weight (%) versus size particle classes of KES and BEH samples
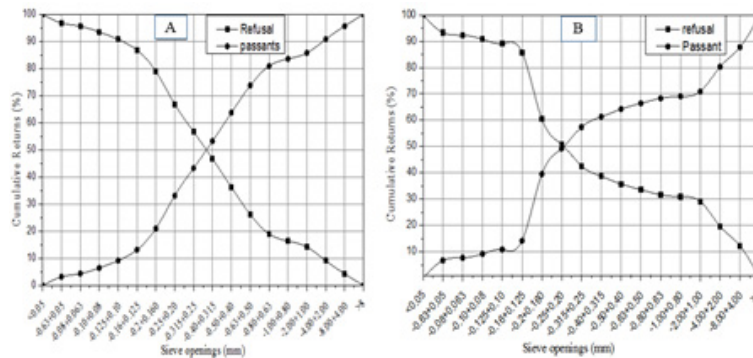Rys. 7. Masa (%) a klasy wielkości cząstek próbek KES i BEH

Fig. 8. Granulometry sieving of the KES and BEH phosphate samples
Rys. 8. Przesiewanie granulometryczne próbek fosforanów KES i BEH

The phosphates of KES consist predominantly of pellets, coprolites, bone debris, oolites and glauconite bound by a calcareous, sparitic or micritic cement.

Depending on the size and nature of the grains, the KES deposit includes three types of facies:

Black phosphate is generally composed of oolites and pseudo-oolites and black pellets with the presence of some coprolites and bone debris. It represents the lower part of the deposit of lower Thanetian age. The black color is due to the presence of organic matter (Figure 6D).

Beige phosphate is characterized by heterogeneity of the grains, and includes pseudo-oolites, glauconite, bone debris and coprolite. These grains are bound by calcareous cement. This type of phosphate is present in the productive sub-layer of the upper Thanetian (Figure 6E).

Dolomitic phosphate. It represents the upper part of the deposit (Figure 6F) and is characterized by the abundance of dolomitic cement with the presence of some coprolites, pseudo-oolites and bone debris.

4.2 Mineralogical and chemical analyses

The phosphatic elements of phosphorites exhibit a great diversity. These elements are peloids, nodules, oolites and oncoids, usually rounded to sub-rounded and lithoclasts, bioclasts and coproids, with less regular forms. The nonphosphatic fraction of the rock is divided into an endogangue included in the previously mentioned phosphatic elements and an exogangue that is external to them [13]. This distinction is important in mining geology because of the different treatment techniques. The endogangue is obviously more difficult to eliminate than the exogangue (example: pelophosphare-

nitis with endogangue pyrite and exogangue of clay rich in organic matter).

4.2.1. Mineralogical analyses

The volumetrically dominant phosphate mineral of Djebel Onk is carbonate fluorapatite [22]. The gangue minerals associated with phosphate particles in the phosphatic rocks are mainly quartz, calcite, dolomite, ankerite, siderite, feldspars, clay minerals, gypsum and organic matter [28].

4.2.2. Particle size analysis

The nature of the phosphate fractionallowsthe selection of the secondary components of the rock, which can be indicated in the name of the phosphorite by adding an adjective: argillaceous pelphospharenite, calcareous phospharenorudite, etc.

The exogangue is extremely variable in quantity, nature and aspect from one deposit to another. It consists mainly of carbonates, silica and silicates.

The endogangueis composed, as a whole, of non-apatitic fraction internal to the phosphatic elements [13].

The most common minerals are opal, quartz, illite and organic matter. The existence of organic matter (OM) in phosphate sediments has been reported by several authors [29-32].

Grain-size classification of the raw phosphates obtained after mechanical treatment and sieving for the two samples, BEH and KES, are reported in (Figure 7)

The distribution of grains in the raw ore is represented by four main modes (M1, M2, M3, and M4) of KES and BEH samples.

The mesh sizes of the phosphate elements are represented by the particle sizes 0.1 mm to 0.5 mm with 42.59 and 64.54%

Tab. 1. Major element contents versus sample size classes from BEH

Tab. 1. Zawartość głównych pierwiastków a klasy wielkości próby z BEH

Fraction	wt (%)									
	P_2O_5	MgO	CaO	SiO_2	Al_2O_3	Fe_2O_3	Na_2O	K_2O	LOI	Total
Total	**23.9**	**3.46**	**45.43**	**5.51**	**0.95**	**0.55**	**1.08**	**0.19**	**18.93**	**100**
> 4	19.92	2.22	48.69	4.61	0.8	0.3	0.64	0.21	22.61	100
- 4 + 2	20.4	4.09	46.56	3.61	2.25	0.29	0.89	0.24	21.67	100
- 2 + 1	22	4.19	47.6	3.91	2.41	0.31	0.68	0.24	18.66	100
- 1 + 0.80	22.4	3.51	47.08	4.32	2.74	0.34	1.21	0.31	18.09	100
- 0.80 + 0.63	22.6	3.42	47.13	4.03	3.29	0.36	1.25	0.35	17.57	100
- 0.63 + 0.50	24.8	3.23	46.01	6.06	4.05	0.34	1.08	0.31	14.12	100
- 0.50 + 0.40	**27.7**	3.12	46.01	5.41	3.19	0.3	1.38	0.33	12.56	100
- 0.40 + 0.315	**29.3**	2.86	47.2	4.16	3.12	0.25	1.36	0.44	11.31	100
- 0.315 + 0.250	**29.5**	2.45	47.89	3.63	2.25	0.2	1.24	0.29	12.55	100
- 0.250 + 0.200	**29.25**	2.15	48.15	3.69	2.07	0.22	1.44	0.32	12.71	100
- 0.20 + 0.160	**29.7**	1.89	49.64	3.41	2.23	0.21	1.35	0.31	11.26	100
- 0.160 + 0.125	**29.95**	1.32	47.26	4.29	3.2	0.34	1.21	0.34	12.09	100
- 0.125 + 0.10	**27.6**	1.2	44.1	4.6	3.5	0.27	1.16	0.56	17.01	100
- 0.10 + 0.08	18	3.25	43.08	5.51	3.28	0.23	0.92	0.57	25.16	100
- 0.08 + 0.063	11.9	4.36	42.2	5.63	3.3	0.22	0.81	0.55	31.03	100
- 0.63 + 0.05	9.1	4.25	41.3	5.77	3.4	0.36	0.75	0.5	34.57	100
<0.05	4.5	4	39.49	6.84	4.43	0.74	0.69	0.48	38.83	100

Tab. 2. Major element contents versus sample size classes from KES

Tab. 2. Zawartość pierwiastka głównego a klasy liczebności próby z KES

Fraction	wt (%)									
	P_2O_5	MgO	CaO	SiO_2	Al_2O_3	Fe_2O_3	Na_2O	K_2O	LOI	Total
Total	**28.23**	**2**	**47.8**	**3.04**	**0.68**	**0.25**	**1.16**	**0.35**	**16.49**	**100**
> 4	19.92	3.86	50.11	3.02	0.68	0.18	0.79	0.23	21.21	100
- 4 + 2	19.68	3.19	47.65	3.24	0.76	0.22	1.06	0.27	23.93	100
- 2 + 1	23.06	3.12	49.52	3.42	0.85	0.23	0.94	0.25	18.61	100
- 1 + 0.80	26.14	3.02	49.07	3.95	0.86	0.26	1.51	0.37	14.82	100
- 0.80 + 0.63	**28.79**	2.99	48.2	4.85	0.78	0.29	1.46	0.39	12.25	100
- 0.63 + 0.50	**29.99**	2.9	47.99	6.13	0.79	0.28	1.30	0.38	10.24	100
- 0.50 + 0.40	**30.19**	2.26	48.61	6.53	0.72	0.26	1.5	0.36	9.57	100
- 0.40 + 0.315	**30.34**	2.15	49.39	4.72	0.69	0.2	1.51	0.34	10.66	100
- 0.315 + 0.250	**30.18**	1.99	49.08	3.32	0.73	0.17	1.13	0.26	13.14	100
- 0.250 + 0.200	**30.01**	1.19	49.57	3.01	0.6	0.18	1.52	0.32	13.6	100
- 0.20 + 0.160	**29.74**	1.02	51.23	3.27	0.71	0.19	1.25	0.3	12.29	100
- 0.160 + 0.125	**28.71**	1	50.69	4.64	0.78	0.27	1.31	0.38	12.22	100
- 0.125 + 0.10	26.33	3.05	50.23	4.7	0.8	0.3	1.37	0.4	12.82	100
- 0.10 + 0.08	24.5	4.13	49.8	4.85	0.83	0.35	1.4	0.47	13.67	100
- 0.08 + 0.063	23.52	4.17	49.58	4.98	0.86	0.38	1.42	0.52	14.57	100
- 0.63 + 0.05	22.88	3.77	47.14	4.55	0.88	0.46	1.1	0.46	18.76	100
<0.05	20.21	2.16	41.66	4.68	0.95	0.61	0.56	0.33	28.84	100

respectively for the two types of the deposits of phosphates (BEH and KES).

The fine fractions smaller than 0,1 mm assigned to the elements of the gangue registered 10,84 and 9,09%, while the coarse fractions greater than 1mm with predominance in sterile elements of the gangue register considerable rates with 29.1 and 14.24% for (BEH and KES) respectively. On the other hand, figure 7 reports the evolution of the weight yield as a function of grain size classes by sieving. From the four granulometric modes, only M1 is the most pronounced. It is assigned partly to dolomite, very abundant in the coarse fraction greater than 1 mm [12].

The secondary modes M2 and M3 where the phosphatic elements are concentrated records proportions of grains with dimensions between 0.08 mm and 0.25 mm. The M4 mode with sizes smaller than 0.1mm is assigned to minerals of the gangue (silica and clay). The obtained output is higher in the intermediate fraction 0.1 to 0.5 mm for (KES) per report/ratio (BEH) which is assigned to the abundance of the phosphatic elements.

In Figure 8 FA, KES deposit illustrates the texture distribution of the rough ore. The percentage of the overall sample mass of KES phosphate ore is >50% and is represented by the range -0.40 +0.315 mm with a grain size class between -0.20 to +0.16 mm. Figure 8B illustrates the texture distribution of phosphates from the BEH deposit. The obtained results indicate that the granulometry is homogeneous. The percentage of the total sample mass of the BEH phosphate ore is >50% and is represented by the range -0.25 +0.20 mm with a grain size class between -0.20 to +0.16 mm.

4.2.3. Granulo-chemical analyses

The elements (oxides) P_2O_5, MgO, CaO, SiO_2, Al_2O_3, Fe_2O_3, Na_2O, K_2O contents of phosphates is directly correlated to the particle-size ranges of the BEH and KES samples, which are given in Tables 1 and 2 .The following observations emerge:

A small population appears in the field from 100 to 60 μm; this is attributed to the presence of dolomite, silica and clays;

A major population is centered around the 200 μm value; this is partly attributed to the phosphate elements of the arenite class.

A small population with coarse grains appears in the range 0.5 to 1 mm, and this corresponds to a mixture of grains consisting of phosphate and dolomite.

The P_2O_5 contents increase with a maximum in the particle size 0.08 to +0.125 mm and -0.500 to +0.100 mm and decrease considerably when the MgO contents increase. The evolution of MgO contents represents carbonates and dolomites located below the phosphatic layer. It seems that the pho-

sphate content increases with the decrease in dolomite and carbonate contents.

Major element contents of BEH and KES samples are given in Tables 1 and 2.

From these analyses, the following remarks can be drawn:

The CaO/P_2O_5 ratio of BEH phosphates of 1.90 is higher than that of KES (1.69). Comparison with the CaO/P_2O_5 ratio of pure fluorapatite [33] indicates the presence of other Ca-minerals;

The KES phosphates are richer in CaO, Corg, and P_2O_5 than those of BEH;

The BEH phosphates show slightly higher MgO, loss on ignition (LOI), SiO_2 and Al_2O_3 contents compared to the KES phosphates;

The contents of remaining elements (Na_2O, K_2O, and Fe_2O_3) are similar in the two deposits.

5. Summary and Conclusions

Two types of phosphate ores were studied by granulo-chemical analyses and X-Ray diffraction (XRD) which allowed performing a comparative study of their granulometry, and chemical properties. The obtained results show that the phosphates grains are mainly coprolites, pseudo-oolites and pellets, bound by a dolomitic cement.

The phosphates of BEH are divided into three sub-layers from top to bottom: (1) the upper section with beige phosphates (UL) is very hard and relatively coarse-grained; (2) the middle section with brown phosphates (ML) is fine-grained and friable; and (3) the lower section with beige phosphates (LL) shows whitish marl intercalations (up to 20 cm). The phosphates of KES are represented by three types of facies: (1) the upper

Thanetian black and (2) beige phosphates; and (3) the lower Ypresian phosphatic dolomites. In terms of particle size, the dimensional classification carried out by sieving revealed that the bulk of the overall mass of the raw ores is represented by the particle size range 0.08 to 0.125 mm and 0.50 to 0.10 mm: 70.36 (KES) and 61.56 % (BEH). This represents the optimal release mesh of separation of the phosphatic elements (class of the arenites).

The mineralogical study on BEH phosphates shows the presence of fluorapatite, hydroxylapatite and dolomite as the main minerals. Quartz, calcite and gypsum are minor minerals. KES phosphates are represented by carbonate-hydroxylapatiteand dolomite as the main minerals. Quartz and calcite are secondary minerals.

The results of the granulo-chemical and by XRD analyses point out the depletion in phosphate content of the layer of BEH and enrichment in carbonate and dolomite content of the BEH deposits compared to the KES deposits.

The CaO/P_2O_5 (1.90) ratio of BEH phosphates is higher than the ones from the KES phosphates ($CaO/P_2O_5 = 1.69$).

Despite the two deposits being located in the same region, each deposit has different mineralogical and chemical characteristics, which will need different method of exploitation in the mining operations.

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Charakterystyka mineralogiczna i chemiczna fosforanów ze złóż Djebel Onk (Tebessa, Algieria)
Algieria posiada ważne rezerwy fosforanów (2 miliardy ton) zlokalizowane na wschodzie kraju w Djebel Onk. Ten obszar górniczy znajduje się w północno-zachodniej części algierskiej Sahary, w pobliżu granicy algiersko-tunezyjskiej. Wyniki analiz granulochemicznych i XRD potwierdzają zubożenie fosforanów w warstwie Bled El Hadba i ich wzbogacenie w węglan i dolomit, w porównaniu z warstwą Kef Essennoun. Cząstki fosforytu są niejednorodnie ziarniste. Chociaż oba złoża znajdują się stosunkowo blisko siebie, wykazują różne właściwości mineralogiczne i chemiczne, co może powodować stosowanie różnych metod eksploatacji górniczej.

Słowa kluczowe: *fosforany, wielkość cząstek, chemia, petrografia, Algieria*