

Influence of grinding on the dissolved phosphoric anhydride content of Tapoa rock phosphate (Niger)

Ousmane Mahamane Sani¹, Abdou Gondah Ismaila², Sanda Bawa Ali¹,
Zanguina Adamou², Natatou Ibrahim^{1,2}

*1*Département de Chimie, Faculté des Sciences et Technique, Université d'Agadez, Niger
*2*Departement de Chimie, Faculté des Sciences et Technique, Université Abdou Moumouni de Niamey, Niger

Abstract:

In the framework of the transformation of natural phosphate from Tapoa (Niger) for use in agriculture, a study of grinding followed by chemical analysis was undertaken. Two representative samples E1 and E2 were collected. The different methods used show on the one hand, that the content of phosphorus pentoxide (% P₂O₅) increases when the diameter of the sieve decreases. On the other hand, the highest content of phosphorus pentoxide is obtained in the fraction between 200-125 μm . These contents are 20.72% for sample E1 and 21.10% for sample E2. These results also indicate that the mass percentage is more important in the fraction below 125 μm (<125 μm). Fluorescence chemical analysis shows a P₂O₅ content of 18.20% and 15.70% respectively in samples E1 and E2.

Mots clés : grinding ; phosphorus pentoxide; phosphate; Chemical analysis

Date of Submission: 05-01-2023

Date of Acceptance: 19-01-2023

I. Introduction

The physicochemical characterization of an ore always requires prior mechanical treatment (crushing, grinding, sieving, cartage, etc.). Primary or secondary crushing aims first and foremost to free valuable minerals from their gangue so that the separation of the latter becomes technically and economically feasible. This technology also aims to create new surfaces for the adsorption of chemical reagents used in flotation separation. The increase in the specific surface of the particles is also expected by these methods [1]. The purposes of this process are diverse, the most important of which are:

- obtaining a specific texture (shape, particle size distribution) [2, 3, 4] ;
- reducing the size of solid particles to facilitate handling, packaging and use ;
- the homogenization of matter.

These last points are the subject of this study. Indeed, as part of the transformation of the natural phosphates of Tapoa for its use in agriculture, a study of the fragmentation of the ore was undertaken in order to improve the release of the useful element: phosphorus. The realization of this work required the use of different methods such as chemical analysis by fluorescence, particle size analysis and colorimetric assay by spectrophotometry.

II. Material And Methods

2.1. Phosphated material

Material used in this study is the natural phosphate ore from Tapoa (Niger), the deposit of which was identified in the 1980 by the National Mining Research Office of Niger [5]. The raw samples (E1 and E2) were collected from old boreholes at coordinates 2°20'33' E and 12°26'0' N. The laboratory samples were taken from the raw ore after grinding and sieving separating the phosphate material from the impurities constitute mostly of clay and siliceous gangue.

2.2. Chemical solutions used

The chemical solutions used in this work are of commercial origin. Their characteristics are given in Table I below:

Table I : Characteristics of the products used

Products	Molar mass (g/mol)	Density	purity	Original
Sulfuric acid	98	1.84	98%	Normapur
Nitric acid	63.01	1.33	52.5	Normapur
Citric acid	192.124	1.66	99%	Normapur
Double Antimony Potassium Tartrate	333.93	-	99%	Acros Organics
Ammonium molybdate [(NH ₄) ₆ Mo ₇ O ₂₄ .4H ₂ O]	1235.86	-	99%	Acros Organics
Ascorbic acid	176.13	-	99.7%	Normapur
Monopotassium Phosphate	136,1	-	99%	Sigma-Aldrich

2.3. Equipment

In this work the following devices were used :

- an energy dispersive X-ray fluorescence spectrometer for chemical analysis ;
- a molecular absorption spectrophotometer for the determination of dissolved phosphorus pentoxide ;
- an analytical balance for measuring masses ;
- a crusher and a series of sieves of different diameters.

Their characteristics are shown in Table II.

Table II: Characteristics of the devices used

Equipment	Model	Manufacturer	Country of origin
Balance	Precisa 205 A	SWISS Quality	Switzerland
spectrophotometer	Model 4101	Zuzi Spectrophotometer	Spain
Crusher	BB-27	E2ME	France
Spectrophotometer	model Minipal 4	Thermo fisherscientific	Canada

2.4. Fluorescence chemical analysis

In order to determine the chemical composition of the raw samples, a chemical analysis was carried out on 5 g of raw powder using an energy dispersive X-ray fluorescence spectrometer. The filters selected were "kapton" for major oxides and "Ag / Al-thin" for trace elements and rare earths. The measurement time for each sample was 100 seconds.

2.5. Particles sizes analysis

A quantity of the raw ore samples undergoes mechanical treatment in a crusher for 30 minutes. A dimensional classification by dry method was carried out with a series of mesh sieves in geometric regression (> 400 ; 400-315 ; 315-200 ; 200-125 and < 125 μm). The level of P₂O₅ as a function of the grain size ranges was determined by the colorimetric method through the formation of the phosphomolybdate complex, after mineralization with nitric acid and sulfuric acid.

2.6. Preparation of the complexing solution

The complexation of the dissolved phosphate ions was carried out using a complexing solution. The method used for the preparation of this solution is that of modified Dabin [6]. Thus a mass of 1.056 g of ascorbic acid is dissolved in 200 ml of reagent prepared from a mixture containing 12 g of ammonium molybdate, 0.2908 g of antimony and potassium tartrate dissolved in 1 liter of demineralized water and 1 liter of 1N sulfuric acid. This reagent is prepared for each use.

2.7. Determination of the content of dissolved phosphorus

In an acidic medium and in the presence of ammonium molybdate, the orthophosphates give a phosphomolybdate complex which is reduced by ascorbic acid and develops a blue color, able of a colorimetric assay. The intensity of the coloration is proportional to the amount of phosphorus dissolved in the reaction medium and is accelerated by the double antimony and potassium tartrate. Thus, 5 ml of the filtrate, 8 ml of the complexing solution are introduced into a 50 ml volumetric flask and then the volume is made with demineralized water. After 10 minutes, the assay is performed using a molecular absorption spectrophotometer at a wavelength of 860 nm according to the modified Dabin protocol [6]. The content of dissolved phosphorus expressed as a percentage of phosphorus pentoxide P₂O₅ is calculated according to the following formula :

$$\%P_2O_5 = \frac{\text{Concentration of dissolved phosphorus} \times \text{Dissolution volume}}{\text{essa weight of the test sample}} \times 2.29 \quad (1)$$

III. Result and discussions

3.1. Chemical composition before grinding

The chemical composition of the raw samples determined using an energy-dispersive X-ray fluorescence spectrometer are reported in Table III. The results obtained show a P₂O₅ content of 18.20% and

15.70% respectively in samples E1 and E2. These results also indicate that the silica content which is respectively 17.30% and 18.70% in samples E1 and E2 is high. The same is true for the ferral mass (% Fe₂O₃ + % Al₂O₃) which is respectively 30.12% and 29.56% in samples E1 and E2.

Tableau III : Chemical composition in major oxides of samples studies

Oxides Composition %	E1	E2
SiO ₂	17.30	18.70
CaO	9.50	11.00
MgO	0.84	0.84
K ₂ O	0.85	0.25
Na ₂ O	ND	ND
TiO ₂	1.43	1.00
SO ₃	ND	ND
P ₂ O ₅	18.20	15.70
MnO	ND	ND
Fe ₂ O ₃	3.22	4.76
BaO	0.89	ND
SrO	4.01	3.53
Al ₂ O ₃	26.90	24.80
LOI	16.60	18.20

LOI : loss of ignition

ND : not detected

3.2. Particle size analysis

The percentages of cumulative refusal and cumulative passing are collated in Tables IV and V and are presented in the form of sectors according to the diameter of the sieves in Figures 1 and 2. These results show that the weight percentage is greater in the section less than 125 µm (<125 µm).

Tableau IV ; Granulometry by sieving for sample E1

Diameter (µm)	Ore mass (g)	Partial refusal (%)	Cumulative refusal (%)	Cumulative passing (%)
> 400	184.0	27.57	27.57	72.43
400-315	50.1	7.50	35.07	64.93
315-200	77.9	11.67	46.74	53.26
200-125	152.7	22.90	69.64	30.36
< 125	202.6	30.36	100	-

Tableau V ; Granulometry by sieving for sample E2

Diameter (µm)	Ore mass (g)	Partial refusal (%)	Cumulative refusal (%)	Cumulative passing (%)
> 400	82.3	15.13	15.13	84.87
400-315	48	8.82	23.95	76.05
315-200	99.8	18.34	42.29	57.71
200-125	142.9	26.27	68.56	31.44
< 125	171	31.44	100	-
Total	544			

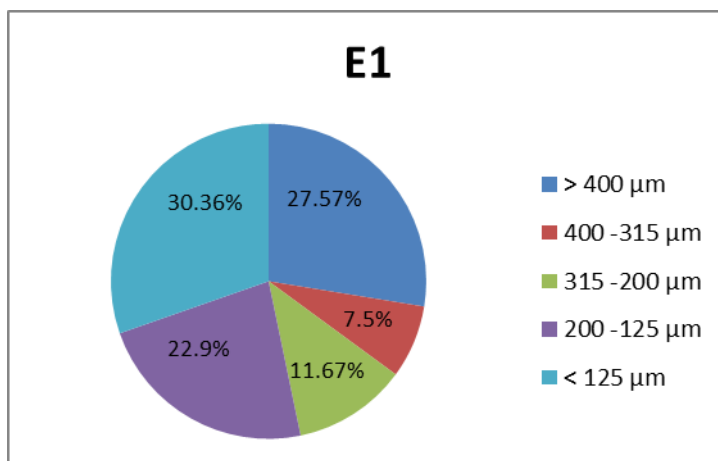


Figure 1 : Sector of particle size analysis of sample E1 after grinding

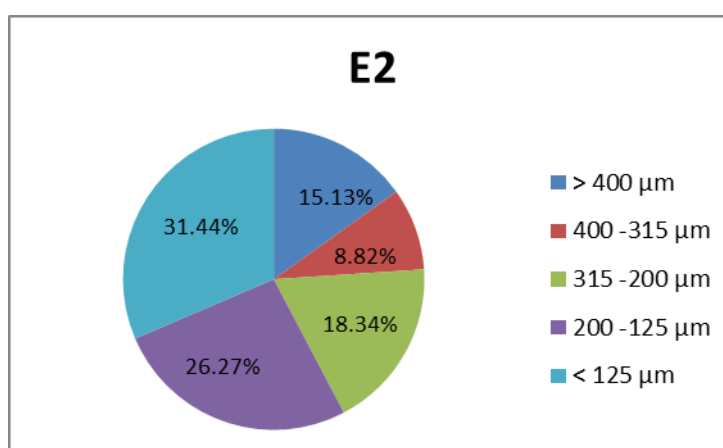


Figure 2: Sector of particle size analysis of sample E2 after grinding

3.3. Phosphorus pentoxide content in the different size fractions

Table VI shows the results of analysis of the phosphorus pentoxide content (%P₂O₅) by the colorimetric method of formation of the phosphomolybdate complex in the different particle size ranges.

Tableau VI : Analysis of %P₂O₅ by particle size range

	E1	E2
Diameter (μm)	%P ₂ O ₅	%P ₂ O ₅
> 400	16.09%	18.28%
400-315	16.43%	18.40%
315-200	19.77%	20.98%
200-125	20.72%	21.10%
< 125	19.32%	19.41%

This analysis shows that the P₂O₅ content increases when the diameter of the sieve decreases from 400 to 125 μm. The best P₂O₅ content is obtained in the range between 200 and 125 μm. Indeed, this content is 20.72% and 21.10% respectively in samples E1 and E2. These P₂O₅ contents are close to those found during chemical analysis, which are 18.20% and 15.70% respectively in samples E1 and E2 (Table III). These results could be explained by the fact that the grinding increases the specific surface [7, 8] by the release of the phosphate elements. Similar results were obtained during the physicochemical characterization of natural phosphates from Tahoua (Niger) [5].

Furthermore, when the diameter is less than 125 μm, a slight decrease in the P₂O₅ content is observed (Table VI). This could be due to the presence in large quantity, in this last section, of minerals considered as impurities such as silica and ferral mass (Al₂O₃ + Fe₂O₃) (Table III).

IV. Conclusion

The various techniques applied (chemical analysis, particle size distribution, colorimetry) have demonstrated a close relationship between the P_2O_5 content and the particle size distribution. The results obtained show that the grinding influences the release of the phosphate elements by increasing the content of phosphorus pentoxide in the particle size fractions.

References

- [1]. Malek B. Nouara, Influence de la matière organique de phosphate noir de Djebel Onk (Tébessa-Algérie) sur le procédé de traitement, thèse doctorat, université de Béjaia, 2007.
- [2]. Bouchaib Semlali, Caractérisation et modélisation spatiale de la broyabilité des massifs rocheux (cas de la mine troilus), université Laval Québec, 2007.
- [3]. Pierre B, Jacques Y, El-Aïd J. Fragmentation - Aspects théoriques, Technique de l'ingénieur (2006) J3050 v1.
- [4]. ANDRES M, Désintégration des roches par impulsions électriques. In « Nouvelles Techniques de Broyage et Économies d'Énergie », éd. AFME, tome 2, 1990.
- [5]. Natatou I, Zanguina A, Ikhiri K, Boos A, Guille J, Rastegar F, Burgard M. 2005. Caractérisation physico-chimique du phosphate naturel de Tahoua (Niger). *Ann. Chim. Sci. Mat*, 30 : 76-67.
- [6]. Mathieu C, Piettain F. 2003. Analyse chimique des sols : méthodes choisies, Ed Lavoisier/Tec & Doc, Paris.
- [7]. Karima B, Compréhension des mécanismes de fragmentation par analyse granulométrique et morphologique, thèse de doctorat, Institut national polytechnique de Lorraine, 1999.
- [8]. Thomas G. Etude multi-échelle de la granulométrie des particules fines générées par érosion hydrique : apports pour la modélisation. Sciences de la Terre, thèse de doctorat, Université de Grenoble, 2012.

OUSMANE Mahamane Sani, et. al. "Influence of grinding on the dissolved phosphoric anhydride content of Tapoa rock phosphate (Niger)." *IOSR Journal of Applied Chemistry (IOSR-JAC)*, 16(1), (2023): pp 56-60.