MINERALOGICAL ANALYSIS OF THE DJEBEL DYR PHOSPHORITES (ALGERIAN-TUNISIAN CONFINES)

[1]BOULEMIA SALIM, [2]HAMIMED M., [3]BOUHLEL S

[1,2]Department of Earth Science and the Universe, University of Tebessa, Algeria
[3]Department of Earth Sciences, Faculty of Science, University of Tunis, Tunisia
E-mail: boulemia_salim@yahoo.fr

Abstract - The sedimentary phosphorites of marine origin mark the Paleo-Eocene period in the region of Tebessa, as elsewhere in northern Africa. The study sector of Djebel dyr is considered a part of the eastern Saharan Atlas. The lithological description of the studied Cups has allowed showing a bundle of phosphate take by carbonate formations with sprinkle of flint. Sorting and litho-morphological observation have identified coprolites, fish teeth, granules, but mainly phosphatic pellets and uncommon non-phosphatic minerals. Analysis by X-ray diffractometry whole rock has confirmed the presence of apatite minerals (hydroxylapatite, Fluroapatite, francolite and dahlite), carbonates (calcite, magnesium calcite, ankerite and dolomite), Quartz, Opal-CT, Zeolites, Feldspar, Clays, Sulphides and Gypsum. Furthermore recounts the RX recordings on the purified grains were identified different mineral phases. Coprolithes and the pellets showed the hydroxylapatite and fluoroapatite sometimes associated with the dahllite, however granules of different forms revealed hydroxylapatite associated fluoroapatite or francolite .Thus, XRD analysis performed on teeth from the phosphate beam Jebel Dyr has overwhelmingly demonstrated the systematic presence of fluorapatite Ca 5 (PO 4) 3F.

Keywords- sedimentary phosphates - Paleo-Eocene - Tebessa - Diffractometry RX - apatite minerals.

I. INTRODUCTION

The sedimentary marine origin phosphates Paleo-Eocene [1] mark the Algerian-Tunisian border region and elsewhere in North Africa. [2] Tunisian researchers [3] [4] [5] [6] [7] [8] [9] and Morocco [10] although thorough scientific knowledge on phosphates also little Algerians were treated the geology of phosphorite [11]. Boulemia in 2015 [12], [13] on phosphates Tebessa could highlight a bundle of 10 mineralized layers of lithological and geochemical varied nature, intercalated limestones and calcareous marl. This study showed that these rocks often belong to the class of phospharénites and sometimes phospharudites. The constituents elements of these allochems sedimentary phosphates Jebel Dyr, are generally, in order of abundance; pellets, coprolites, the lithoclasts and fish teeth. The present work has been individualized to know and to better elucidate the mineralogy of the total phosphate rock and its allochems constituents.

II. GEOGRAPHIC CONTEXT AND GEOLOGICAL

The study area "Djebel Dyr Oriental" is part of the Saharan Atlas of eastern Algerian-Tunisian border. This synclinal line extends in Tunisia. It's 20km of distance northeast of the capital of the province of Tebessa. The main geological formations encountered at the Jebel Dyr site are Cenozoic age [14] [15] (Danian "e^1" Selandian "e^{2-3}" and Thanetian "e4" (Fig.1).

III. MATERIALS AND METHODS USED

To make a relevant mineralogical analysis 22 samples of relatively friable phosphorite, were taken from the site of Jebel Dyr East. Samples phosphorites allow optimum screening after disintegration simple to extract the coarse fraction "phospharudites" namely; fish teeth, and coprolites lithoclasts. The calcined sediment is passed through a series of nested circular sieve metallic background. After careful consideration under binocular, pellets apatite be distinguished. This preparation was conducted in the laboratory of geosciences at the University of Tebessa.

The separated samples are ground to a particle size of 30 mm. The resulting powder was analyzed by X-ray diffractometer, model X'Pert Pro PanAnalytical at the Research Unit of the Faculty of Sciences of Tunis. The type of acquisition parameters used is routine analysis (step = 0.02 ° and time / No = 20s) for the identification and quantification of different crystalline phases present in a sample. The X-ray diffraction pattern obtained from a multi-phase powder is compared by computer with all the basic data sheets using a program "HighScoreplus" .The database used is the Powder Diffraction File (PDF) with more than 164 000 cards, published in 2004 by the International Center of diffraction Data (ICDD). Determining the crystallographic parameters of a given phase is performed using the same software.

IV. RESULTS AND DISCUSSION

The particles or allochems highlighted and which will be subject to this approach are: a (Fig. 02). a- The coprolites, of various shapes: cylindrical, round, oval, spiral, conical, and irregular shapes: b- phosphate pellets of arenites size and spherical or ovoid shape with the rounding of the imperfect surface. c. fish teeth of sizes and varying shapes and are in most cases completely phosphate's. A test to determine the

species of these "sharks and rays" was made in any force. [16] d. Lithoclasts : They are hard to break, beige or gray with a black patina and luster similar to large pebbles and is characterized by any typical form and may be likened at first to lithoclasts phosphorite.

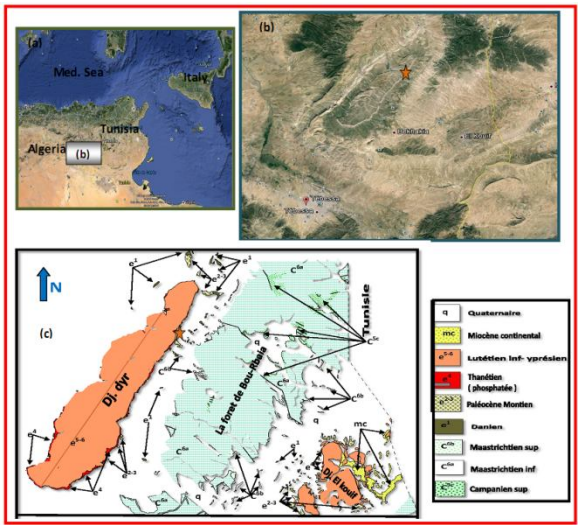


Fig. 1. (a) ,(b) Location of the studied region. (c) Simplified geological map of the Tébessa Basin (extract from geological map of Algeria 1/50,000). Red star: The studied Djebel Dyr oriental section.

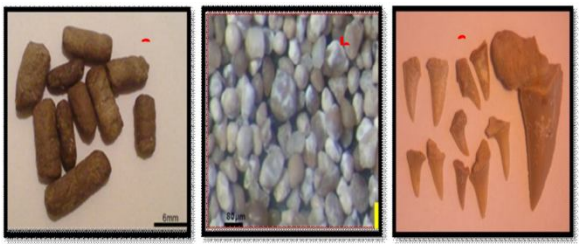


Fig. 2 Photographs of the main allochems of Dyr phosphorites illustrating; a- coprolith, b- pellets and c- Chalk Teeth.

The XRD analysis performed on samples from the whole rock and its various components from the phosphate beam Djebel Dyr showed results as Suits:
1. Diffractometry of whole rock: The analysis highlighted the following main groups of minerals (Figure 03)
1.1. Apatite (hydroxylapatite, fluorapatite, and francolite dahllite), carbonates (calcite, magnesium calcite, dolomite and ankerite) The silica (quartz and cristobalite - trydimite), sulphides (Pyrite-Cinnabar-Covellite) and Gypsum.
* The hydroxyapatite Ca 5 (PO 4) 3 (OH): Mineralogical study by X-ray diffractometry of the total rock phosphorite, as well as grains purified phophatés has overwhelmingly shown the almost systematic presence of Hydroxylaptite. Main lines of the mineral occurring in the studied diffractograms correspond to the lattice planes or most intense peaks as follows: (211), (300), (112), (202), (102), (210), (130) , (222), (100), (312), (213), (200), (231), (140), (402), (004), (502). (002). The predominant mineral occurs either single or associated with fluorapatite, francolite and dahllite. Other non-phosphate minerals, gangue constituents exo-What are coexisting carbonates, of Silica, of sulfates and sulfides.
* The fluoroapatite Ca 5 (PO 4) 3 F: This mineral,

Table I. Crystallographic parameters of different Apatite of Jebel Dyr

Minéral	a et b	C	c/a	Maille	Emperical formula
Fluoroapatite	9.371	6.885	0.734	523.12	$Ca_5(PO_4)_3F$
Hydroxylapatite	9.352	6.882	0.735	521.26	$Ca_5(PO_4)_3(OH)$
Francolite	9.340	6.880	0.736	519.77	$CaF(Ca,C)_4[(P,C)(O,OH,F)_4]$
Dahllite	9.450	6.885	0.725	532.09	$(Ca_{9.35}Na_{1.07})(PO_4)_{5.46}(CO_3)_{1.36}O_2$

associated with hydroxylapatite, apparently mainly characterized by the wealthy nival bioclastes (tooth and bone fragments).
* The francolite CaF (Ca, C) $_4$ [(P, C) (O, OH, F) $_4$]: rarely appears at the El Kouif phosphtés layers, it is associated with the hydroxylapatite. Apparently, it will feature more quantitative dominance in our field compared to those of North Africa.
* The dahllite ($Ca_{9.35}$ $Na_{1.07}$) (PO4) $_{5.46}$ (CO_3) $_{1.36}O_2$: This mineral of calcium-phosphate present soduim carbonate crystallographic parameters (a and c) relatively higher than those of other apatites (Table 01) .This may be due to strong chemical substitutions . The dahllite is rarely found in the RX records associated with hydroxylapatite and quartz. Substitutions that affect the sedimentary apatites are frequent and directly influence the symmetry of the crystal lattice which result in changes to the parameters a and c [17]. The decrease in the crystallographic parameter of the apatite (Table 01) may be labeled by substitutions; F - OH, O - 2 OH, Ca - Na, PO_4 - CO_3. Effectively, our results Jebel Dyr not contradict this view.

1.2. The carbonates are present in the form of calcite, magnesium calcite, ankerite and dolomite. Calcite is characterized by its main line (104) at a distance of 3.058. Sometimes the main peak (29,179 °) shows a slight shift towards large angles. This displacement results from the incorporation of the magnesium and / or iron in the calcite structure. Indeed, the magnesium calcite is marked to 29.50 °, dolomite to 30,815 ° to 30,819 ° ankerite (Table 02). Associations ; Calcite-Ankerite, calcite-dolomite-calcite and magnesium calcite are recorded on the same samples that provide information on matasomatiques phenomena dolomitisation and dédolomitisation. Thus, it should be noted that dolomite and magnesium calcite characterize cherty levels by associating with opal (tridymite). Furthermore, as was encountered rarely, a soda-aluminous carbonate hydroxylated "dawsonite" NaAl (CO3) (OH) 2, associated with the zeolite and anorthite.

Table II. Crystallographic parameters of different carbonates of Jebel Dyr

Minéral	Hkl	d (A°)	2 Θ	Chimical formula
Calcite	104	3.0360	29.395	Ca (CO3)
Calcite magnés.	104	3.0254	29.500	(Ca0.97Mg0.03) (CO3)
dolomite	104	2.8893	30.815	(Ca Mg)(CO3)2
Ankérite	104	2.8890	30.819	Ca (Mg0.67 Fe0.33) (CO3)2

1.3. Free silica: The Quartz α is identified by its main line (011) at 3.33 A °. It is often associated only with apatite (HA, FA, FR and Dahllite) and sometimes in the presence of cristobalite and ankerite. He probably has a detrital origin. However other varieties of opal (Cristobalite- tridymite) met in high levels in cherty levels accompanied dolomite and magnesium calcite, its origin is probably biochemical.

1.4. Sulphate: The gypsum known with its main peak (200), d (6003 A °) and 2Ɵ (14,745) is sometimes encountered in diffracogramme , And was observed at a single phosphatized sample. Fluorine-sodium sulfate Na_3Ca_2 (SO_4) $_3F$ associated with the graphite (Fig.04). Presumably, the gypsum is of secondary type. This can result, in an arid climate, precipitation of rain water enriched with sulphates when runoff from overlying formations. Especially, the evaporite formations are one of the traits that characterize this region of diapirs of Algerian-Tunisian border.

1.5. Sulfides: Pyrite-Cinnabar-Covellite at levels apparently low (trace) are detected on the RX records of some samples of the same vertical profile by well individualized peaks (Figure 4). Moreover, the association (Cu-Hg-Fe) is confirmed in the region under the expression of hydrothermal polymetallic mineralization.

1.6.The zeolite: alumina silicates are hydrated minerals .The occasionally observed on the diffractograms are: Cowlesite ($CaAl_2Si_3O_{10}$ $.6H_2O$), Yugawaralite (Ca (Si_6Al_2) O_{16} $.4H_2O$) Offretite K1.04Ca1.04Mg0.98 (Al5 .1Si12.9O36) (CO) 0.88. Indeed, these zeolites have seen summers associated with palygorskite and anorthite in the presence of apatite. The origin of this type of minerals in the Tebessa basin is very controversial. But the most likely is the volcanic origin as interpreted approach SASSI in the Gafsa basin [8].

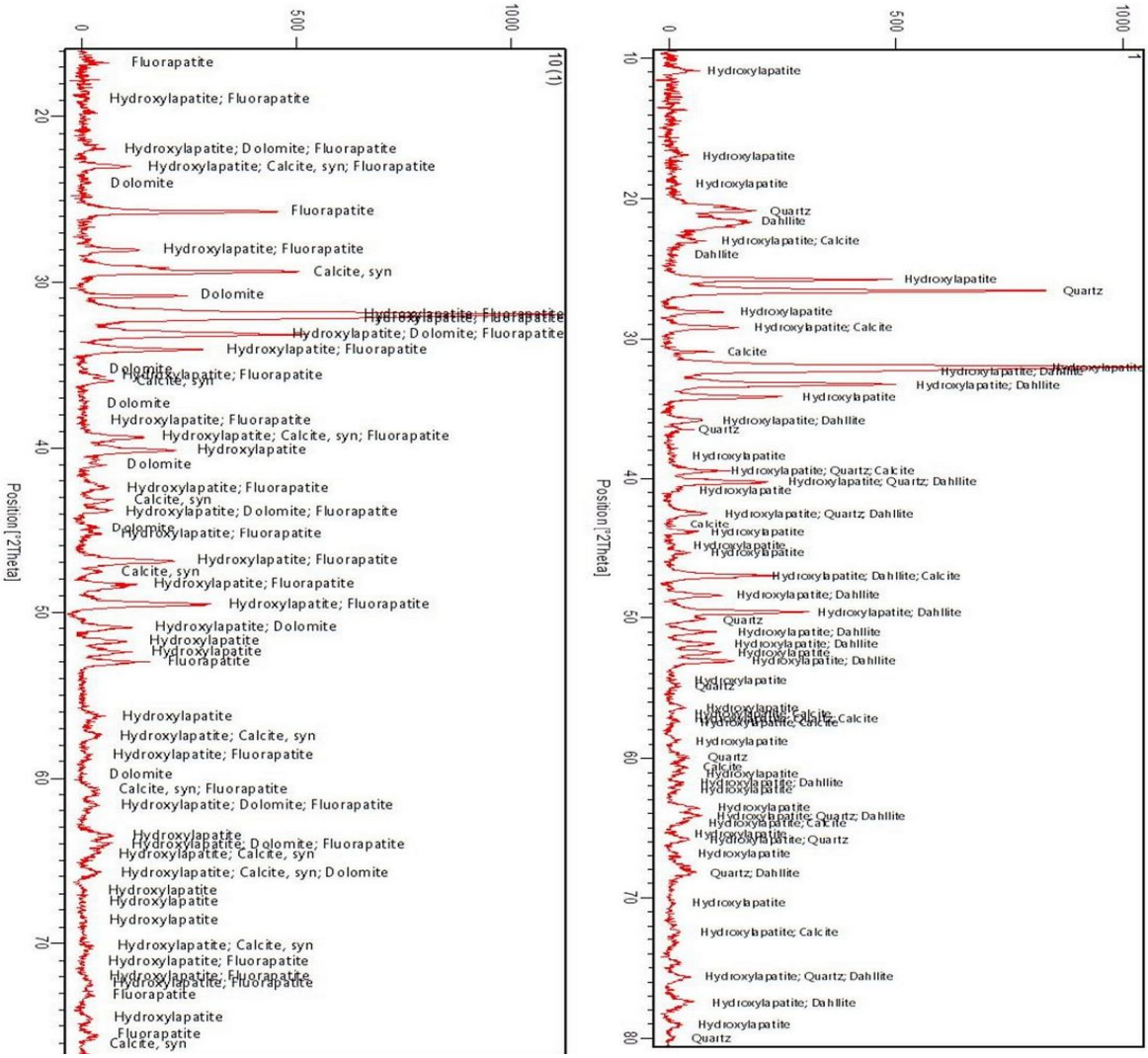


Figure 03: Examples of X ray diagram for phosphorite sample show the apatitic different component with carbonates and siliceous gangue of Dyr sector.

1.7. Clays: concerning these phyllosilicates was met only palygorskite $Mg_5Si_8O_{20}$ (OH) $_2$.$8H_2O$. The latter has been recognized by its main line position of 8.5 ° on difractogrammes some phosphate samples. The other types are absent which requires a priori oriented plates heated and glycol.

1.8. Feldspar: It's anorthite $(Na_{0.84}Ca_{0.16})$ $Al_{1.16}Si_{2.84}O_8$, which was met occasionally associated with Yugawaralite and dawsonite. This mineral soda-lime brands its maximum intensity at 29.7 °. The magmatic makes more sense especially in the presence of zeolites.

1.9. Graphite: This carbon hexagonal system is recognized by its main line at 26.6 ° .Its presence is rarely associated with apatite fluoride and hydroxyl apatite. Its existence indicates a confined environment rich in organic matter.

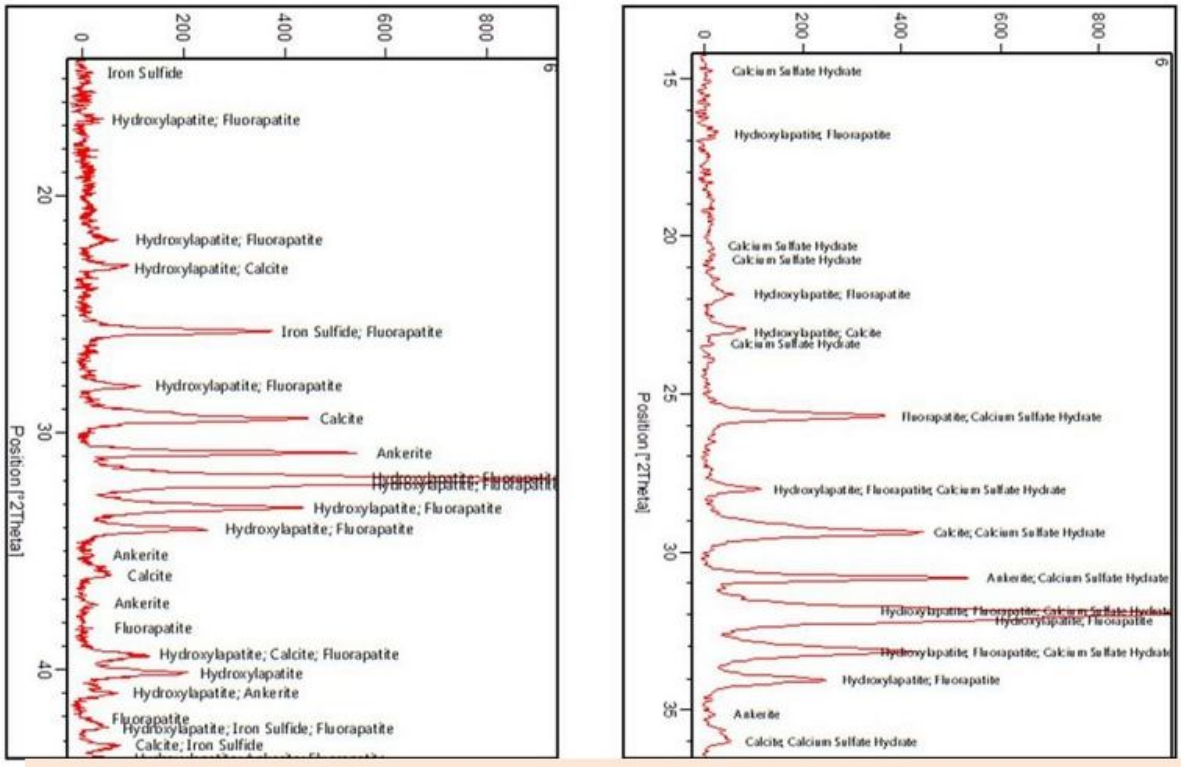


Figure 04 a, b,: Examples of X-ray patterns showing the presence of sulfides and sulfates in phosphate

samples Djebel Dyr sector.

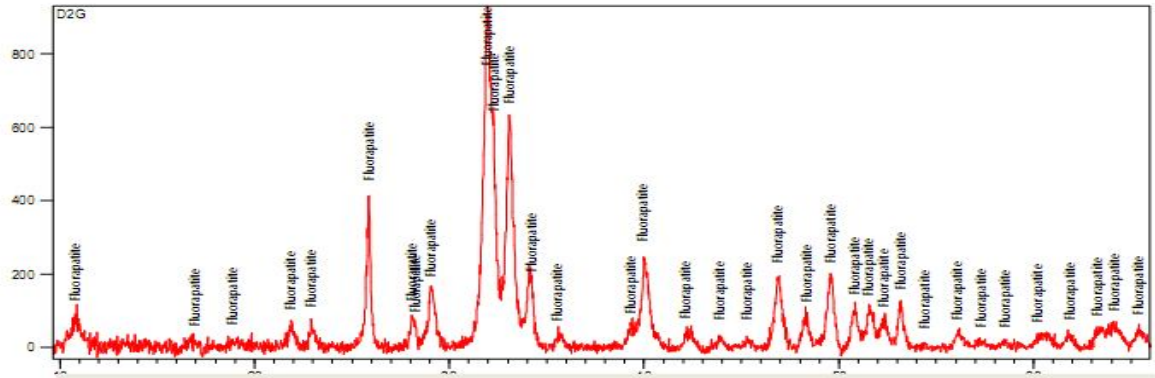


Figure 05. Example of X-ray diagram of a high tooth sample from the Djebel Dyr sector showing one apatite component (Floroapatite)

2. diffractometry teeth: Analysis XRD RX performed on samples from the teeth phosphate beam El Kouif and dyr has overwhelmingly demonstrated the systematic presence of fluoroapatite Ca5 (PO4) 3F (Figure 05). The crystallographic parameters means of the mesh are 9371 to 6885 and a and b to c. Main lines of the mineral occurring in the studied diffractograms correspond to the lattice planes or most intense peaks as follows: (211), (300), (112), (202), (102), (210), (130) , (222), (100), (312), (213), (200), (231), (140), (402), (004), (502). (002). apparently this mineral characterizing these bioclastes suggests likely that the teeth not undergone significant changes and / or significant structural

changes in the phosphatogenesis. Indeed, Kesmez [18] found that the fluorapatite is the only mineral

3. Coprolites diffractometry: XRD analysis RX performed on various forms isolated coprolites friable phosphorite phosphate from the beam el kouif and dyr, showed that these fossil feces consist of hydroxylapatite and fluorapatite sometimes associated with Dahllite in the presence of calcite.

constituent of the species that have lived in the Atlantic Ocean during the Tertiary.

4. Diffractometry granules and pellets: The XRD analysis RX made on granules (greater than 2mm) of different shapes and sizes indicated that the latter are represented by the hydroxylapatite associated with fluorapatite or francolite (Fig. 6).

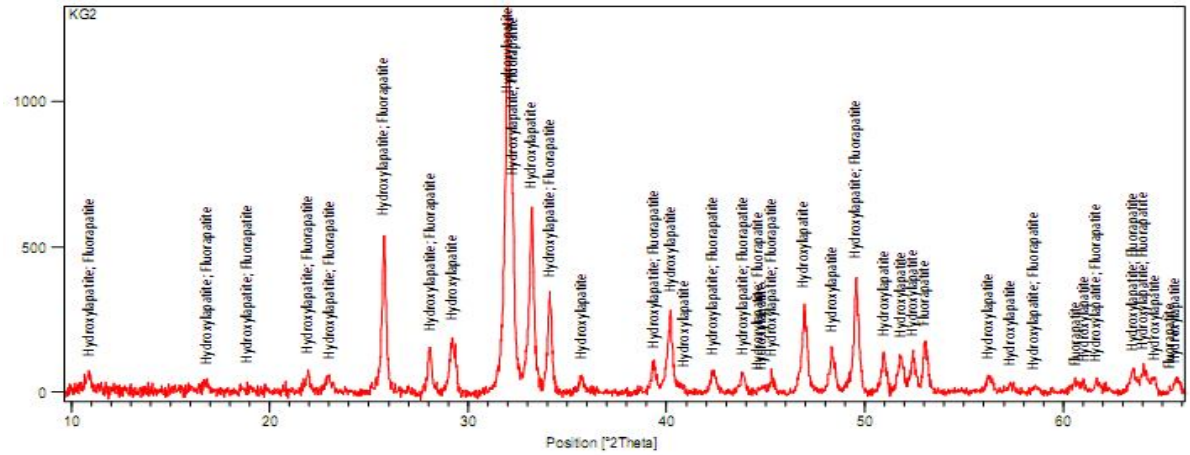


Figure 06: Example diagram RX a sample of phosphate from the granule of Djebel Dyr sector.

CONCLUSION

One of the Paleo-Eocene accumulations phosphate in Algeria is that of Jebel Dyr area. This is part of the north-east of the Algerian-Tunisian border. The lithological description of the studied cuts allowed us to distinguish essentially, a phosphate beam collected by carbonates and sometimes interspersed with cherty levels.

The mineralogical analysis by X-ray phosphate samples has identified the structure and the crystallographic parameters by calling our apatite components mainly to the hydroxylapatite. Meanwhile, was met sporadically fluorapatite, francolite and dahllite surtouts through rich levels bioclastes. Apatitic these components are associated mainly carbonates (calcite, dolomite, ankerite) and / or silica which form exo matrix at varying rates. Opal-CT is associated with dolomite, may be due to the high influx of siliceous test organisms (radiolarians, diatoms ... Etc.). Locally, sulphides (Pyrite-Cinnabar-Covellite) and sulphate (gypsum) are observed at low representation through some samples.

The existence of minerals such as: zeolites, palygorskite, dawsonite and Sod-fluorinated Sulfate in Tébessa basin is attached has priori, environmental enrichment for Sodium, aluminum, magnesium, potassium and silica. Under favorable physicochemical conditions, these can rush to give birth to these types of minerals. The origin of the chemical elements is probably associated with the alteration of igneous rocks known in the Tebessa region under the name of ophites.

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