

ABSTRACT TEMPLATE

SCIENTIFIC CONFERENCE "IDEAS AND INNOVATIONS IN EARTH SCIENCES"

We remind you that Abstracts are submitted only in English!

The total length, including figures and all references, is limited to **three pages**. The submitted abstract should be in a Microsoft Office Word file (*.doc, *.docx). Page format: A4 (21,0 x 29,7 cm).

General recommendations for the format of the abstract

- Margins. Top and Bottom: 2 cm; Left and Right: 2 cm.
- Paragraphs. Single line spacing; indent 1 cm.
- Font. Authors names (Arial Bolt, font-size: 12 pt, text-align: justified left and right); Affiliations (Arial Italic, font-size: 10 pt, text-align: justified left and right); Title (Arial Bolt, All caps, font-size: 14 pt, text-align: justified left and right); Main text (Arial, font-size: 10 pt, text-align: justified left and right).
- Figures and Photos. Abstract may include figures, photographs, tables (a caption should be attached to each).
- Acknowledgement. Arial Italic, font-size: 10 pt. After the main text and before the references.
- Citations. Arial, font-size: 10 pt. Cite references using square brackets [1]. Examples of the format of references list are given below.

General template

Author¹ , Author² , Author¹

(1) Affiliation, e-mail

ABSTRACT TITLE

Main text

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References

1. Author A.A., Author B.B., Author C.C. Title of article. Title of Journal, 2010. V. 00, № 00. P. 10-20.
2. Author A.A. Title of monograph. City: Publisher, 2010. 90 p.
3. Author A.A. Title of theses // Conference or other event. City: Publisher, 2010. P. 3-4.

Detailed template is on the next page...

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APPLICATION OF X-RAY DIFFRACTION AND XPS SPECTROSCOPY FOR IDENTIFICATION OF MINERALS OF APATITE

Industrial deposits of apatite ores in Ukraine are quite limited in distribution and are associated with carbonate and gabbroids of the Proterozoic age of the Ukrainian Shield [1]. In Ukraine they are represented by the following types: rare metal-apatite carbonatite and apatite-ilmenite-titanomagnetite gabbro-anorthosite [2].

Ukraine's current demand for phosphorus raw materials is estimated to be 6-7 million tons, [3] as for the conditioned apatite concentrate. This raw material is not mined in Ukraine, so it is mainly imported. It is astonishing that the largest country in Europe with enormous areas of chernozem and developed agriculture, with an annual demand (according to various sources) of 0.7-1.7 million tons of P_2O_5 , must import apatite concentrate, phosphates and phosphate fertilizers, possessing phosphorite and complex apatite deposits, nor being properly exploited [3].

The raw material resources of Ukraine originate from five regions of ilmenite-apatite that is - Kropyvnianske, Stremygorodske, Torchynske, Fedorivske (Zhytomyr region), Nosachivske (Cherkasy region); and two, where apatite is considered as an accompanying mineral, one apatite-rare metal ore deposit - Novopoltavske (Zaporizhzhya region) and Davydkivske deposit (Zhytomyr region) and the apatite-ilmenite ore, where apatite is investigation the main mineral (Figure 1.) [1]. All deposits are multicomponent and during the investigation it is planned to recover all useful components. As besides to apatite, these deposits contain ilmenite, which is a critical raw material, as well as scandium and vanadium.



Fig. 1. Map-scheme of location of apatite ore deposits (according to [1], with edits of the authors)

In the study apatite was identified by X-ray diffraction and XPS spectroscopy. Based on the obtained diffraction pattern and diffraction database ICDD PDF4+2021, the identification of the crystalline phase present in the studied mineral was made. The XPS-spectroscopic tests were also carried out to determine the elemental composition of the test sample as well as the chemical bonds formed by the elements contained in the mineral.

Apatite is a mineral from the group of phosphates of the general chemical formula $\text{Ca}_5[\text{F,Cl,OH}](\text{PO}_4)_3$. Depending on the elemental composition, there are: fluoroapatite - $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{Ca}(\text{F,Cl})_2$, hydroxyapatite - $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{Ca}(\text{OH})_2$ and carbonate apatite - $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{CaCO}_3$ [4].

Apatite ores are an important source of phosphorus-containing raw materials [3], which are used as a raw material for the production of mineral fertilizers, feed as well as technical phosphates, yellow phosphorus and phosphoric acid in various industries, especially in chemical one [5]. The results of diffraction tests are presented in Figure 2 and Table 1.

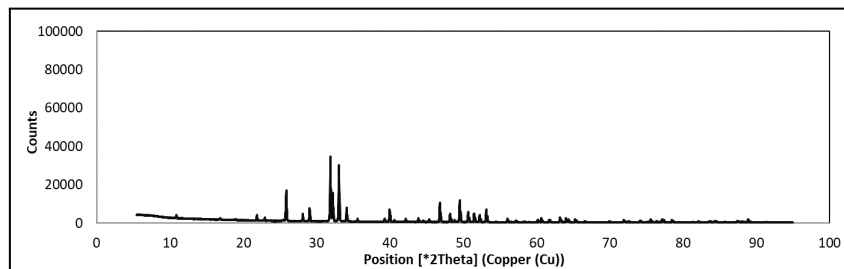


Fig. 2. Powder radiograph of the apatite sample

Table 1. Comparison of the obtained diffraction pattern with the diffraction database ICDD PDF4+2021

No.	Code Ref	The name of the compound	Chemical formula	quantity [%]
1	01-083-6195	fluoride phosphate	$\text{Ca}_5(\text{PO}_4)_3\text{F}$	100

To identify the elemental composition and chemical bonds of the mineral sample, XPS spectroscopic tests were carried out using a multi-chamber UHV analytical system (Table 2). Tests showed the presence of carbon (25.5%), oxygen (38.4%), fluorine (2.6%), phosphorus (14.8%) and calcium (18.7%).

Table 2. Identification of chemical bonds typical of apatite is determined on the basis of the XPS spectra made in a narrow range of binding energies

Name	Position	% concentration of atoms	Bonds
P 2p 3/2	132.96	50.5	PO_4^{3-}
P 2p 1/2	133.82	49.5	PO_4^{3-}
1s A	531.26	90.51	P = O
1s B	533.05	9.5	P-OH / PO-
2p 3/2	347.29	51.12	$\text{CaO} / \text{CaCO}_3$
2p 1/2	350.87	48.88	$\text{CaO} / \text{CaCO}_4$

XRD and XPS tests revealed that the sample was fluoroapatite with the formula $\text{Ca}_5(\text{PO}_4)_3\text{F}$.

The use of X-ray diffraction and XPS spectroscopy to identify minerals on the example of apatite makes it possible to effectively isolate the highest quality apatite ores in order to provide the state with its own minerals.

References

1. Mineral resources of Ukraine - Kyiv, State Research and Production Enterprise "State Information Geological Fund of Ukraine", 2018. 270 p.
2. Salnikov V.D., Bordyugov V.P. Phosphate raw materials (geological and economic review). Kiev: Geoinform. 1995. 55 p.
3. Site of the National Association of Extractive Industries of Ukraine (NAPA) [Electronic resource]. - Mode access: <http://neiau.org/apatyty-ukrayiny-syrovyna-dlya-vlasnyh-dobryv/>
4. Elliot J.C., Wilson R.M., Dowker S.E. Apatite structures. International Center for Diffraction Data 2002, Advances in X-ray Analysis, Volume 45, 2002. P. 172
5. Donelik R.A., O'Sullivan P.B., Ketch R.A. Analysis of apatite separation tracks. Reviews of mineralogy and geochemistry Vol. 58, 2005. P. 49.