KISATIBI DIATOMITE DEPOSIT

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Abstract. Kisatibi diatomite deposit is built up of white, fine-striped, light gray, and gray varieties. Based on the comprehensive laboratory and technological studies we conducted, the uniqueness of the white variety of diatomite found in the Kisatibi deposit is clearly established, from which valuable high-quality products can be derived, including filter powders.

Key words: Kisatibi deposit; diatomite; tuff.

საკვანძო სიტყვები: ქისათიბის საბადო; დიატომიტი; ტუფი.

გაფართოებული რეზიუმე

ქისათიბის (საქართველო) დიატომიტის საბადო. ნ. ჩომახიძე,ნ. ფოფორაძე. ქისათიბის დიატომიტის საბადო აგებულია მიო-პლიოცენური ასაკის ვულკანოგენებით (გოდერძის წყება). წყების ზედა ნაწილში განლაგებულია დიატომიტის შემცველი 5 ფენა.

დიატომიტის შემცველი ქანი, მაკროსკოპულად ნაცრისფერი, ფხვიერი, სუსტად შეცემენტებული, საშუალო მჟავიანობის ლითოკრისტალოკლასტური ფოროვანი ტუფია, რომელიც გვხვდება დიატომიტის თეთრი, წვრილზოლებიანი, ღია ნაცრისფერი და ნაცრისფერი სახეობის სახით. თეთრი ფერის ნიმუშები, მიკროსკოპში ერთგვაროვანია, მთლიანად წარმოდგენილია მღვრიე, თითქმის იზოტროპული ოპალისებრი მასით, რომელიც მცირე რაოდენობით შეიცავს წმინდამარცვლოვან, კრისტალურ მექანიკურ მინარევს (α-კრისტობალიტი, Ca-მონტმორილონიტი, Ca-Na - მინდვრის შპატი). წვრილზოლებიანი, ღია ნაცრისფერი და ნაცრისფერი სახეობები ნატეხური აგებულებისაა, ზოგჯერ მათში როგორც ცალკეული მინერალის (ძირითადად, პლაგიოკლაზი და რქატყუარა), ასევე ქანის სხვადასხვა ზომის ჩანართები გვხვდება.

გასულ საუკუნეში, ქისათიბის დიატომიტის საბადოზე მოპოვება როგორც ღია კარიერული წესით, ასევე მიწისქვეშა სამთო გამონამუშევრებით მიმდინარეობდა. ნედლეული, ძირითადად, მიეწოდებოდა საცემენტე მრეწველობას, ცემენტში ჰიდრავლიკური დანამატისათვის, ხოლო მცირე ნაწილი გამოიყენებოდა ქიმიურ მრეწველობაში. ქისათიბის უნიკალური თვისებების მქონე დიატომიტის ასეთი არარაციონალური გამოყენება არ იყო მიზანშეწონილი.

ჩვენ მიერ ჩატარებული კომპლექსური ლაბორატორიული და არსებული ტექნოლოგიური კვლევების საფუძველზე, ნათლად იკვეთება ქისათიბის დიატომიტის საბადოს შემადგენელი დიატომიტის თეთრი სახესხვაობის უნიკალურობა. საველე სამუშაოებით, დრონით მიღებული სურათებისა და 3D მოდელების ანალიზით დადგინდა საბადოზე არსებული პრობლემები (ნაკარიერალების და ჩამდინარე წყლების პრობლემა, ჩამოქცეული შახტები და ა.შ.). მათი აღმოფხვრა კი მხოლოდ საბადოს ინვესტიციით, თანამედროვე ტექნოლოგიების გამოყენებით დამუშავებისა და მიღებული პროდუქტის რეალიზებით იქნება შესაძლებელი.

თეთრი დიატომიტისაგან შესაძლებელია მივიღოთ მაღალხარისხოვანი ძვირად-ღირებული პროდუქცია: საფილტრე ფხვნილები შაქრის ხსნარების, ზეთის, ხილის წვე-ნების, ღვინის, ლუდის გასაწმენდად; იგი შეიძლება წარმატებით გამოვიყენოთ მედიცი-ნაში გლიცერინის და ინსულინის გასაწმენდად, სინთეზური ბოჭკოს, ქაღალდის, რეზი-ნის, საღებავისა და სხვ. პროდუქციის წარმოებაში. დიატომიტისაგან დამზადებული პროდუქცია ექსპორტისთვისაც იქნება გამიზნული.

ქისათიბის საბადოს რენტაბელური დამუშვება ხელს შეუწყობს ადგილობრივი მოსახლეობის დასაქმებას და რეგიონის ეკონომიკურ განვითარებას.

INTRODUCTION

The Kisatibi diatomite deposit is located in the Akhaltsikhe municipality, in the vicinity of the villages Tskordza, Andriatsminda, and Uraveli (Fig. 1). It occupies one of the prominent places among the non-mineral deposits of Georgia. Only this deposit of diatomite is included in the state balance sheet of mineral resources (Gamkrelidze, 1964; State balance of mineral reserves, 2022).

The deposit is distinctive and unique due to the chemical composition and technological properties of its white diatomite. It is one of the largest deposits of industrial significance, not only in the Samtskhe-Javakheti region, but also of global importance (Tvalchrelidze, 2006).

Fig. 1. View of the Kisatibi field from above (photo by drone).

The Akhaltsikhe municipality is characterized by moderately cold winters and relatively hot summers. The average annual air temperature ranges between +6-7°C.

The main water artery of the deposit region is the Uraveli River and its left tributary, the Kisatibi River, which flows in the central part of the area (Geological report, 1963).

The Kisatibi diatomite deposit is associated with the same named asymmetric fold, which is built by the Kisatibi Formation of Upper Miocene-Lower Pliocene age. The older Upper Eocene sediments are present in the northern part of the deposit, dipping southward beneath the Kisatibi Formation (Fig. 2, 3).

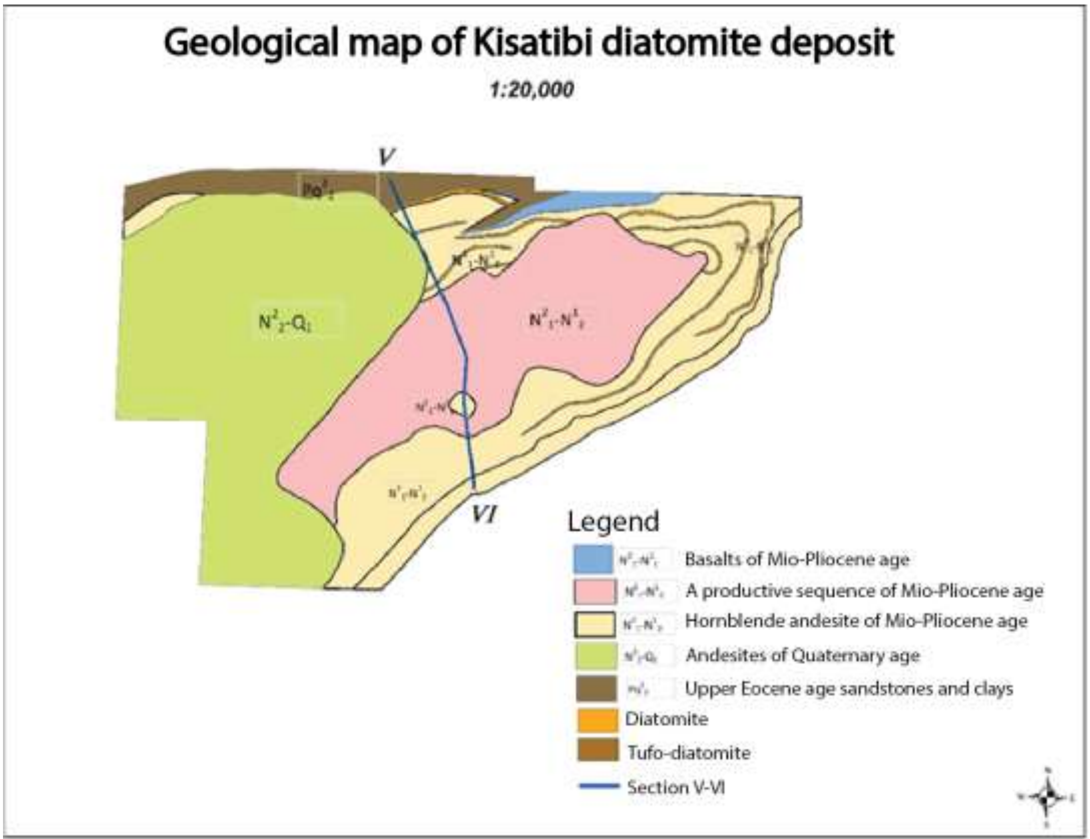

Fig. 2. Geological map of the Kisatibi diatomite deposit.

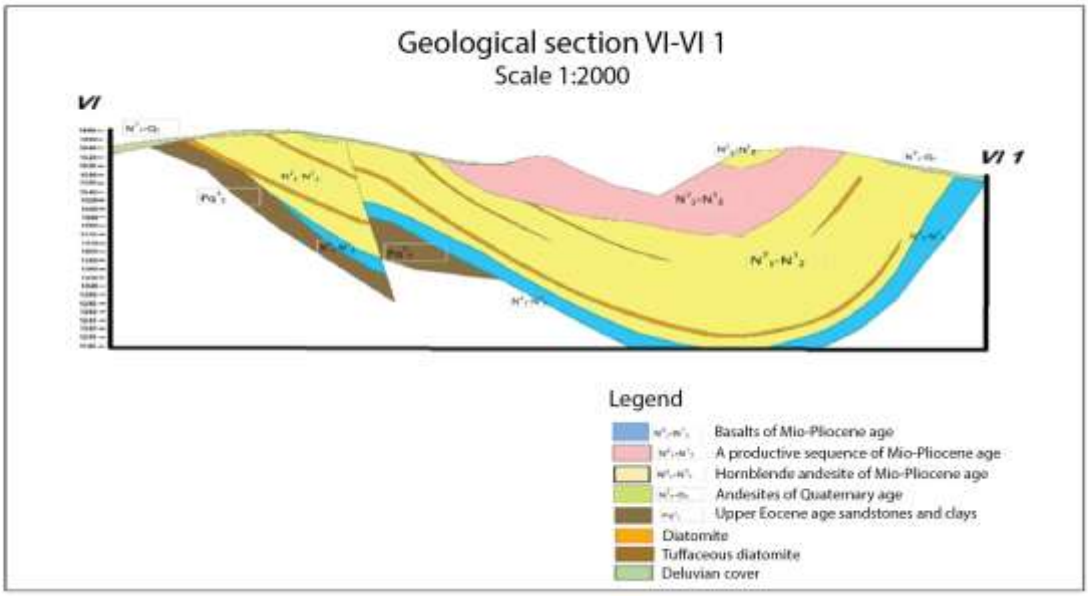

Fig. 3. Geological section of the Kisatibi diatomite deposit.

The upper part of the Kisatibi formation contains five diatomite layers, with the lower layer being of the highest quality (Fig. 4). The thickness of this layer varies from 2.5 to 12.5 meters in different areas of the deposit.

Fig. 4. The upper area of the Kisatibi field (section).

The deposit is geographically located on a plateau, the terrain flattens in the northeast and southeast directions. The relief slopes in the opposite direction to the inclination of the syncline-bearing rocks. Outcrops of productive layers are found on the northern, eastern, and southeastern slopes (Geological report, 1963).

At the deposit, diatomite occurs as white, finely-striped, light gray, and dark gray varieties. White diatomite has the best chemical characteristics, containing on average 90.75% SiO_2 and 1.51% Fe_2O_3+FeO. The finely striped variety contains, on average, 85.39-87.45% SiO_2 and 2.45% Fe_2O_3+FeO. The other varieties have a similar composition, with an average of 78.65% SiO_2 and 3.76% Fe_2O_3+FeO. Among the ore minerals fine grains of limonitized pyrite are present (Geological report, 1963).

Visual inspections and interviews with former workers revealed that the underground infrastructure in the Kisatibi mine is damaged, and the entrance to the mine has completely collapsed. As a result, we could not enter the tunnel and assess the current situation.

The rocks containing diatomite are lithocrystalloclastic (of medium acid composition) and crystalloclastic tuffs. The former (Fig. 5) appears macroscopically light gray, with a fragmentary structure and visible inclusions of various colors. It is porous, easily decomposes, and does not react to hydrochloric acid.

In the microscope, the rock exhibits a clastic structure and is porous, with fragments of varying sizes and compositions. These fragments consist of both individual minerals and rock fragments. Plagioclase and hornblende grains of different sizes are most commonly found. Plagioclase is predominantly polysynthetic, with occasional zonal twins, while hornblende is often replaced by iron hydroxide. Large rock fragments, primarily of effusive origin, display characteristic porphyry and diabase structures (Fig. 6). This combination of minerals and textures is similar to volcanic formations found in the volcanic regions of Georgia, such as those in the Javakheti Plateau.

Fig. 5. Outcrop of lithocrystalloclastic tuffs.

Fragments of andesite with characteristic structures and mineral compositions are often observed in the tuffs. In some cases, fragments are so extensively replaced by secondary material that their original form becomes unrecognizable. Areas replaced by iron hydroxide and clay can be found intermittently. Additionally, ore mineral grains of varying sizes are present, and most of the pores appear to be free.

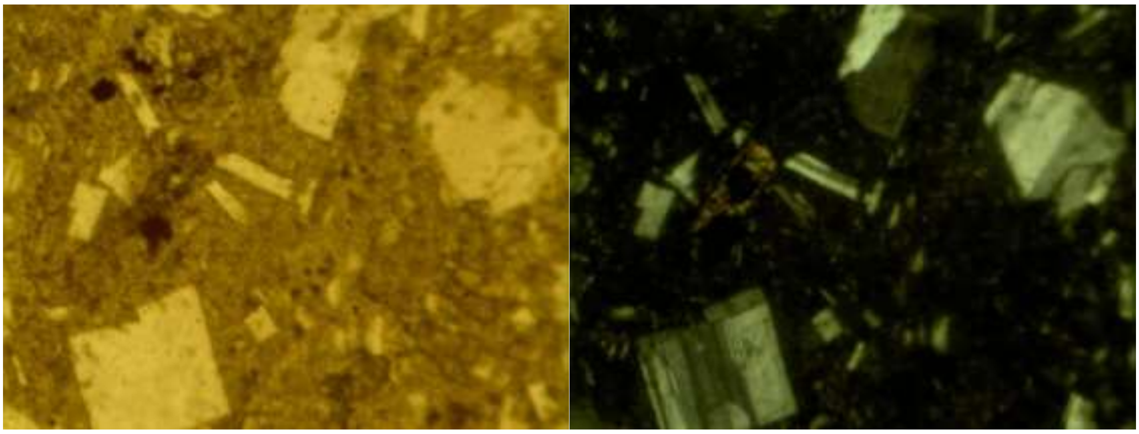

Fig. 6. Lithocrystalloclastic tuff sample (№ 1) in a polarizing microscope. a) PPL; b) XPL.

In the X-ray phase analysis radiograph, the lithocrystalloclastic tuff sample (No. 1-d) is characterized by the presence of Ca-Na feldspar, Ca-montmorillonite, an X-ray amorphous phase, and α-cristobalite (Fig. 7).

Lithocrystalloclastic tuff appears macroscopically light gray, with a fragmentary and porous texture. It is easily decomposed and does not react to hydrochloric acid.

In the microscope, the rock exhibits a fragmentary, turbid, and porous texture. The fragments are small and of varied composition, consisting of both individual minerals and rock fragments. The mineral composition is dominated by small grains of plagioclase, often displayed as polysynthetic twins, along with smaller quantities of quartz and hornblende. The rock fragments are primarily of effusive origin and are small in size, showing characteristic porphyry and diabase structures. In some cases, the main mass of these fragments is completely replaced by iron hydroxide and clay. Throughout the rock, grains of ore minerals of different sizes can be observed, with most of the pores remaining free.

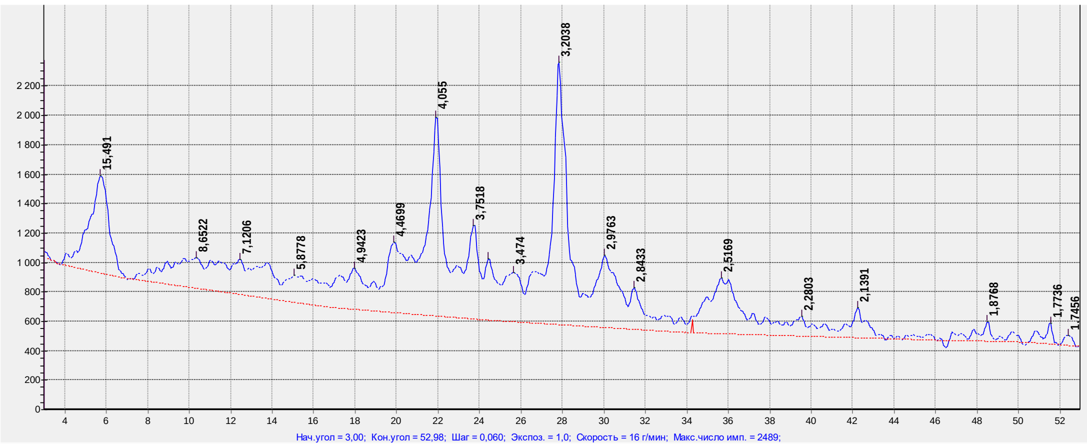

Fig. 7. X-ray phase analysis radiograph of lithocrystalloclastic tuff sample (№ 1-d).

Crystalloclastic tuff is macroscopically light gray, with a fragmentary and porous texture. It is easily decomposed and does not react to hydrochloric acid (Fig. 8).

Fig. 8. Outcrop of crystalloclastic tuff.

In the microscope, the rock (sample No. 12) appears fragmentary, turbid, and porous. The fragments are small and of varied composition, primarily consisting of various minerals, with rock fragments being rare. The mineral composition is dominated by plagioclase grains of different sizes, often displayed as polysynthetic twins (Fig. 9).

The tuff is primarily composed of quartz and hornblende grains. The rock fragments are mostly of effusive origin, displaying characteristic porphyry and diabase structures. In some areas, there is an increased presence of clay and iron hydroxide. Rarely, grains of ore minerals of varying sizes can also be found. Outcrop of tuffs containing diatomite (upper area) (Fig. 10).

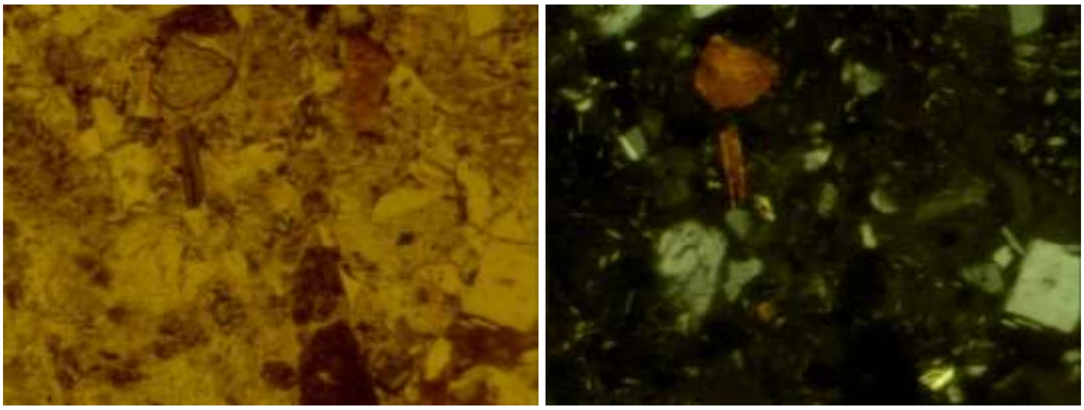

Fig. 9. Sample of crystalloclastic tuff (№ 12) in a polarizing microscope. a) PPL; b) XPL.

Fig. 10. Outcrop of the diatomite layers (upper area) of the Kisatibi deposit.

Macroscopically, diatomite appears gray, loose, weakly cemented, fine-grained, and homogeneous, containing plant remains and abundant marine animal armor (sample 2-d). It does not react with hydrochloric acid and is of marine origin, sedimentary, and layered. In the microscope, the rock is homogeneous (Fig. 11), primarily consisting of a cloudy, almost isotropic mass (opalic cristobalite and α-cristobalite) with a small amount of fine-grained mechanical inclusions (Fig. 12).

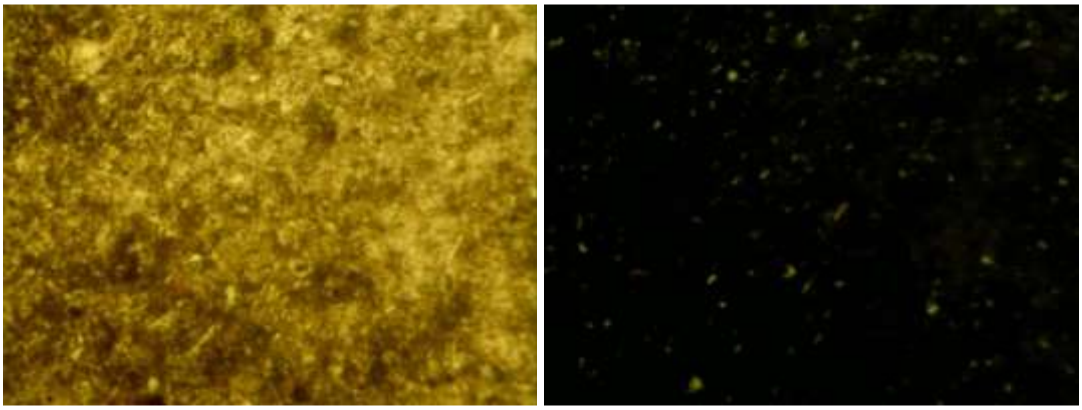

Fig. 11. Diatomite sample (№ 2) in a polarizing microscope. a) PPL; b) XPL.

On the radiogram of the X-ray phase analysis of the diatomite sample are cristobalite, Ca-Na feldspar, Ca-montmorillonite (trace), X-ray amorphous phases (Fig. 12).

Outcrop of tuffs (lower area) containing striated, gray fine-grained diatomite (Fig. 13).

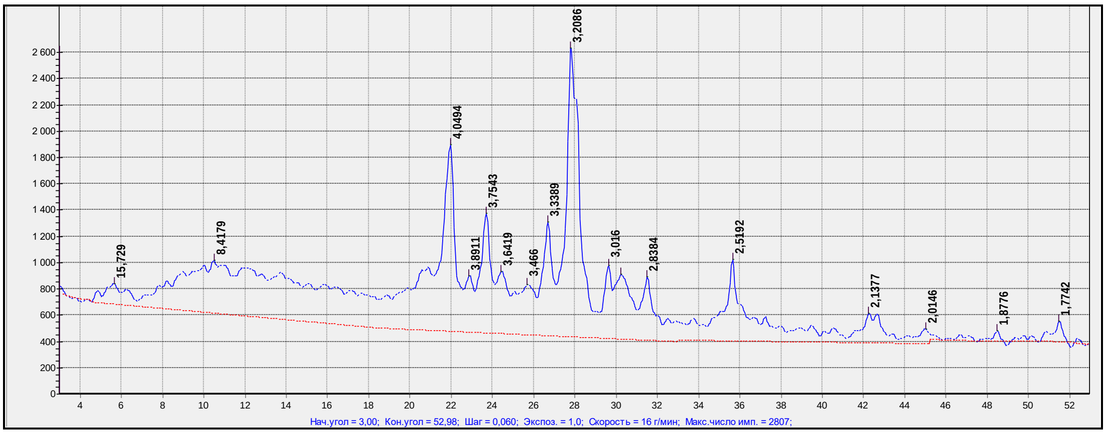

Fig. 12. Diatomite sample (№ 2) radiograph of X-ray phase analysis.

Fig. 13. Outcrop of diatomite-containing layers of Kisatibi deposit.

Outcrop of tuffs containing diatomite (lower area) (Fig. 14). Macroscopically the sample N6 is striped, gray, fine-grained and does not react to hydrochloric acid.

In the microscope, the diatomite is uniform and predominantly consists of a turbid, isotropic matrix containing minor amounts of mechanical material, represented by small grains of quartz and feldspar. In some areas, there is an increased content of clay or organic material (Fig. 15).

Fig. 14. Outcrop of layers containing diatomite (lower area) of Kisatibi deposit.

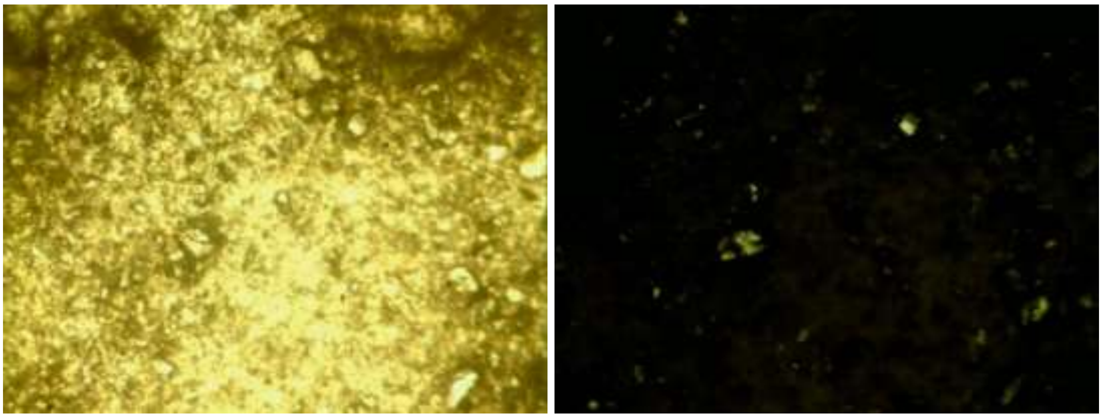

Fig. 15. Diatomite sample (№ 6) in a polarizing microscope. a) PPL; b) XPL.

Diatomite (Sample 7) appears macroscopically light gray, fine-grained, homogeneous, and does not react with hydrochloric acid.

In the microscope, the rock is homogeneous and consists entirely of a turbid isotropic groundmass containing fine-grained mechanical material. This material includes small grains of quartz and feldspar (plagioclase, occasionally with polysynthetic twins). In some areas, there is an increased amount of organogenic material (Fig. 16). Microscopically, it is similar to other samples.

Macroscopically, diatomite (sample 11) is white, fine-grained, homogeneous, and does not react with hydrochloric acid.

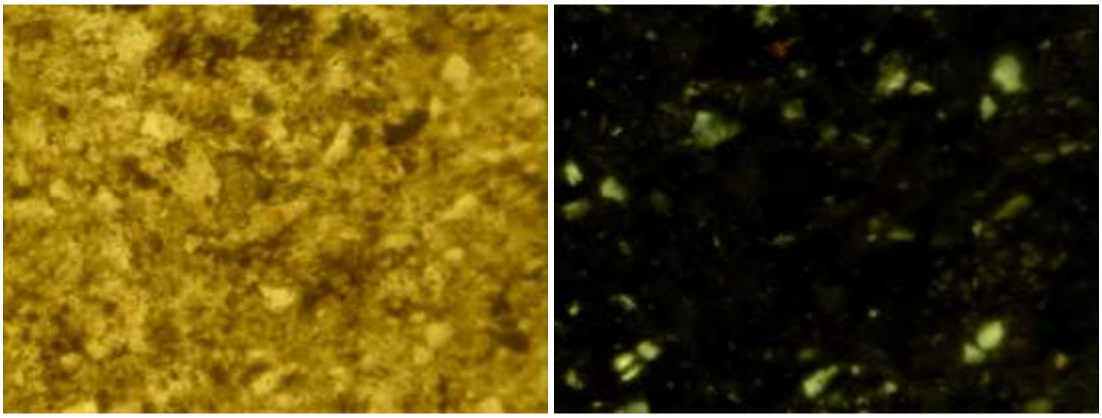

Fig. 16. Diatomite sample (№ 7) in a polarizing microscope. a) PPL; b) XPL.

In the microscope, the diatomite is inhomogeneous, with a turbid, isotropic groundmass containing fine-grained mechanical inclusions. One fragment is likely entirely composed of cristobalite (Fig. 17).

The x-ray phase analysis of a sample of white fine-grained diatomite shows cristobalite phases, and Ca-Na feldspar, Ca-montmorillonite (trace), X-ray amorphous phases at the trace level (Fig. 18).

The chemical composition of diatomite was determined by X-ray fluorescence analysis: White diatomite: SiO_2 – 91.35-88.75%, Fe_2O_3+FeO – 1.81-1.57%; Striated diatomite: SiO_2 – 86.75-79.45%, Fe_2O_3+FeO – 2.72-2.55%; Gray diatomite: SiO_2 – 77.88-57.35%, Fe_2O_3+FeO – 3.90-67.35%.

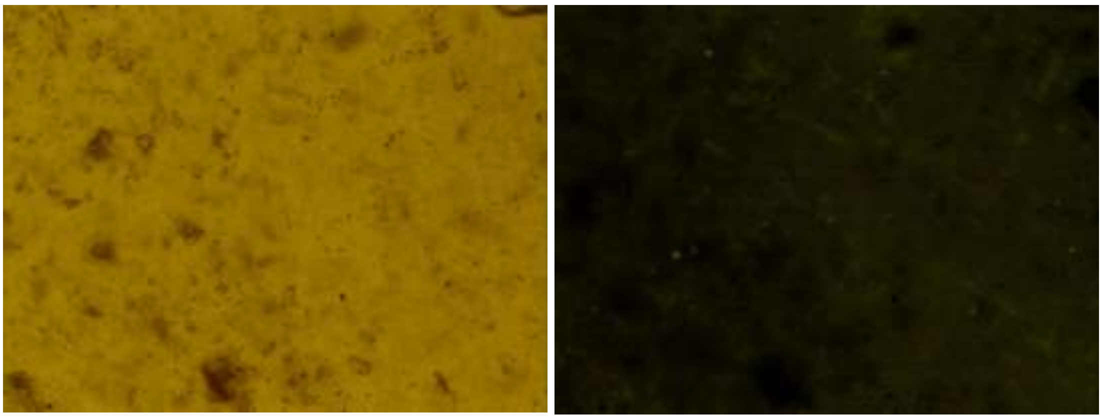

Fig. 17. Diatomite sample (№ 11) in a polarizing microscope. a) PPL; b) XPL.

According to geological fund data, the geological study and industrial development of the deposit began in the late 20s of the 20ieth century. Exploration works were first conducted in 1929, which delineated the small eastern flank of the deposit. In 1930, the Central Stocks

Commission approved reserves in categories A and B, amounting to 158,000 tons (Geological report, 1963). Mining commenced on a small scale and artisanal basis in the 1930s.

According to the results of re-exploration conducted in the same area in 1946, the reserves were confirmed by the Territorial Commission of "Saqgeology" in 1948, amounting to 1,578 tons in categories A+B+C1, and C2 (State balance of mineral reserves, 2022).

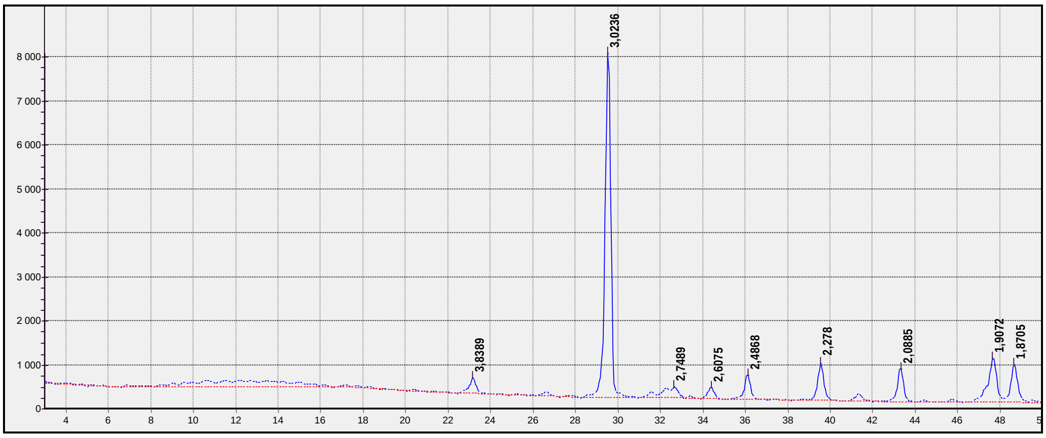

Fig. 18. X-ray phase analysis radiograph of diatomite sample (№ 11).

From 1955 to 1962, in response to increased demand for diatomite, additional exploration work was carried out to enhance the prospectivity of the deposit. The State Reserves Commission subsequently approved the reserves in categories A+B+C1, and C2, totaling 11,158 tons (State balance of mineral reserves, 2022).

In the following years (1977-78), reserves were actively increased, and industrial categories were strengthened. Ultimately, in 1982-83, as a result of work conducted under the mining assignment for the deposit, the reserves in its northwestern part increased: category B to 554,000 tons, C1 to 252,000 tons, and C2 to 157,000 tons (State balance of mineral reserves, 2022).

From 2000 to 2004, the deposit was worked intermittently on a small scale, resulting in the extraction of 12 thousand tons of diatomite ore. Extraction methods included both open-pit mining and underground operations. The raw material, supplied mainly in flake and ground forms, was primarily used in the cement industry as hydraulic additives, while a small portion was utilized in the chemical industry.

Such irrational use of the high-quality white and thin-striped diatomite from the Kisatibi deposit was inappropriate, especially considering its uniqueness as a raw material due to its quality (high flint content, low levels of iron and other oxides, etc.). Mining has been halted since 2004.

As of January 1, 2024, the diatomite reserves are as follows (in thousand tons): category A–456; B–960; C1–456; C2–39; totaling 8,380 000 tons (State balance of mineral reserves, 2022).

Based on our fieldwork and comprehensive laboratory studies, along with analysis of drone images and 3D models (Fig. 19), we clearly identify several issues at the deposit, including problems with sewage and wastewater and the collapsed entrance to the mining area. Addressing these challenges will require investment and the application of modern technologies for processing the deposit. Therefore, given the existing complex geotechnical conditions, it is essential to re-explore the deposit and reassess the reserves according to modern standards. This will enhance data reliability, evaluate its potential, and determine the prospects for processing.

Using a drone (Phantom 4), the surface of the deposit was scanned, and a modern 3D projection was created (Fig. 19). This was then compared with the digital data from the detailed exploration report of the deposit. The topography of the deposit is depicted as it was at the time of the reserves approval (Fig. 20, 21).

Fig. 19. A modern 3D model of the topography of the Kisatibi deposit.

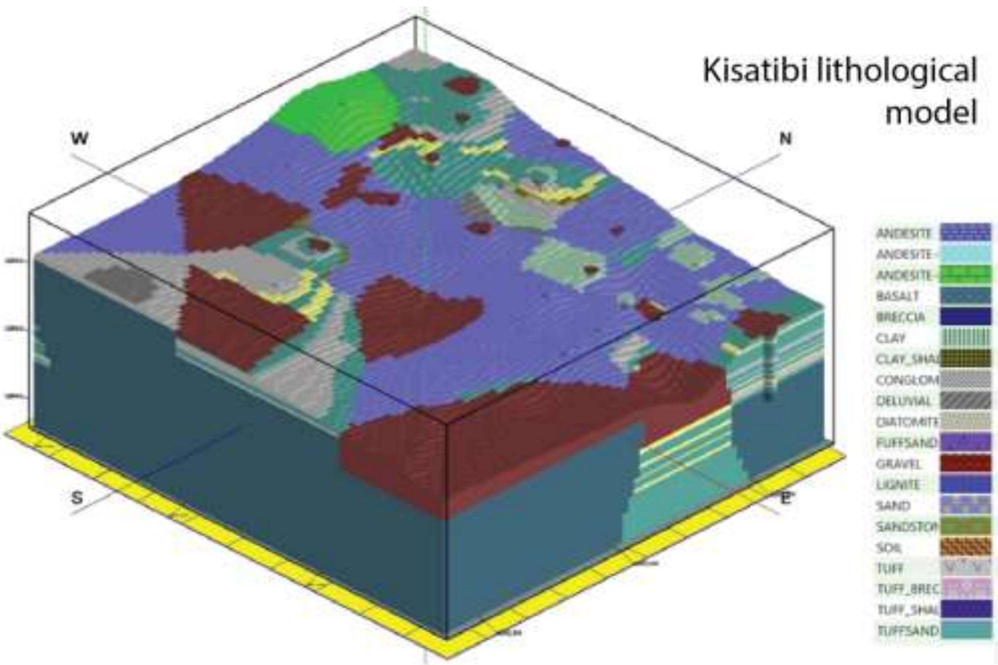

Fig. 20. 3D model model (projection) of the Kisatibi deposit based on the detailed exploration report.

The comprehensive laboratory and technological studies conducted on Kisatibi diatomite samples clearly indicate that high-quality, valuable products can be derived from these raw materials. These include filter powders suitable for purifying sugar solutions, oils, fruit juices, wines, and beers, as well as important fillers for the production of chromatographic solid carriers. Additionally, diatomite can be utilized in medicine for the purification of glycerin and insulin, as well as in the treatment of lactam waters. It also plays a role in the production of synthetic fibers, paper, rubber, paints, and other products. The diatomite products will primarily be aimed at export markets.

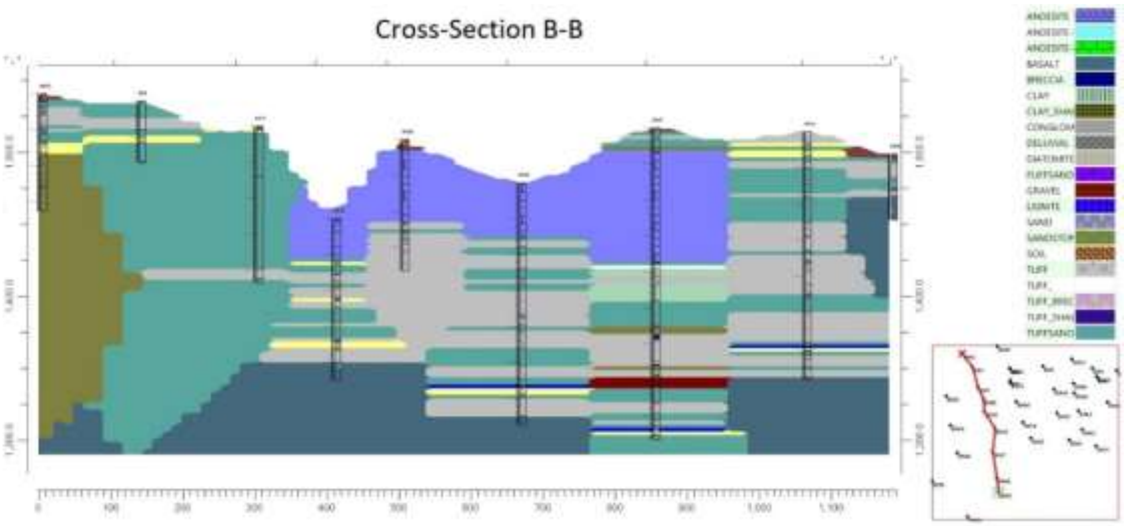

Fig. 21. Lithological section of the Kisatibi deposit.

The Kisatibi deposit was explored according to the standards applicable in the former Soviet Union. Given the current conditions in the field, it is essential to revalidate the reserves according to modern international standards and the JORC Code. Although 8,380,000 tons of ore are currently recorded in the Kisatibi deposit, this figure does not accurately reflect the real situation, making it impossible to determine the amount of remaining reserves. Through our research and analysis of state geological fund materials, we were able to estimate the approximate amount of extracted raw materials.

During the inspection of the deposit area, we observed that the bottom of the pit has turned into a pond due to open-pit mining, highlighting significant wastewater issues. The entrance to the mine is closed, preventing us from conducting inspections or taking samples. Therefore, it is crucial to restore the mining access and reassess the deposit according to modern standards, as its further licensing, operation, and the reliability of the study depend on this reevaluation.

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