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ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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SYNTHESIS OF IMPORT-SUBSTITUTING BLUE ULTRAMARINE BASED ON MINERAL RAW MATERIALS FROM UNIQUE DOMESTIC DEPOSITS

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Abstract. Ultramarine pigment, although it is a widely demanded scarce material, is not produced in Kazakhstan, and huge needs are met through imports from other countries. Meanwhile, inorganic mineral pigments are among the priority materials in the State programs of industrial and innovative development of the Republic of Kazakhstan.

To ensure high environmental friendliness, reduce costs it is advisable to use affordable and widespread pure natural raw materials. Therefore, studying the possibility of synthesizing silicate pigments based on selected highly effective mineral raw materials types and identifying patterns of solid-phase reactions during synthesis is an actual.

The basis of scientific research consisted of mineralogical, petrographic and chemical analyses, petrochemical calculation of charges and comprehensive studies of the obtained samples.

Original kaolin and silica raw materials were selected. The proposed synthesis advantage is to improve the charge technological qualities due to the use of high–grade kaolin and marshallite, which has a natural fine dispersion, high reactivity and ensures of chemical and solid-phase reactions throughout the entire volume of the charge at lower temperatures. The use of these components in the charge made it possible to obtain a bright saturated blue pigment and reduce its cost. The obtaining blue ultramarine possibility from local natural mineral raw materials has been demonstrated for the first time.

The introduction of the developed technology for the synthesis of ultramarine pigment will solve the import substitution problem.

Key words: lapis lazuli, ultramarine, inorganic pigment, mineral raw materials, kaolin, marshallite

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БІРЕГЕЙ ОТАНДЫҚ КЕН ОРЫНДАРЫНЫҢ МИНЕРАЛДЫҚ ШИКІЗАТЫ НЕГІЗІНДЕ ИМПОРТТЫ АЛМАСТЫРАТЫН КӨК УЛЬТРАМАРИН СИНТЕЗІ

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Аннотация. Ультрамарин пигменті кеңінен сұранысқа ие тапшы материал болғанымен, Қазақстанда әлі толық өндірілмейді, ал орасан зор қажеттіліктер басқа елдерден импорт есебінен қанағаттандырылады. Сонымен қатар, бәсекеге қабілеттілікті қалыптастыруды, өңдеу өнеркәсібі салаларының номенклатурасын кеңейтуді және технологиялық дамуын көздейтін Қазақстан Республикасының индустриялық-инновациялық дамуының соңғы жылдардағы мемлекеттік бағдарламаларында бейорганикалық минералды пигменттер басым материалдар қатарында.

Жоғары экологиялық тазалықты қамтамасыз ету, өзіндік құнын төмендету және өндірістің технологиялық процестерін оңтайландыру үшін қол жетімді және кең таралған таза табиғи шикізатты қолданған жөн, алайда бүгінгі күні керамикалық пигменттер жоғары температуралы синтезді қолдана отырып қымбат синтетикалық химиялық заттардан жиі алынады. Сондықтан минералды шикізаттың таңдалған жоғары тиімді түрлеріне негізделген силикатты пигменттерді синтездеу мүмкіндігін зерттеу және синтездегі қатты фазалық реакциялардың заңдылықтарын анықтау өзекті мәселе болып табылады.

Отандық пайдалы қазбалардың ішінен шикізаттың түпнұсқалы каолин және кремнеземды түрлері – ультрамарин синтезінің негізгі компоненттері таңдалды. Ұсынылған синтездің артықшылығы – жоғары сортты каолинді және осы технология үшін жаңа табиғи жоғары дисперсиялы, жоғары реактивтілігі бар және төмен температурада шихтаның бүкіл көлемі бойынша химиялық және қатты фазалық реакциялардың толық жүруін қамтамасыз ететін кремнезем-маршаллит көзін пайдаланумен шартталған ультрамарин шихтасының технологиялық қасиеттерін жақсарту. Бұл компоненттерді шихтада қолдану ашық, қаныққан көк пигментті алуға және оның құнын төмендетуге мүмкіндік берді. Алғаш рет минералды шикізаттың жергілікті табиғи түрлерінен көк түсті ультрамарин алу мүмкіндігі көрсетілді. Ультрамарин пигментін синтездеудің дамыған технологиясын енгізу импортты алмастыру мәселесін шешуге мүмкіндік береді.

Түйін сөздер: лазурит, ультрамарин, бейорганикалық пигмент, минералды шикізат материалдары, каолин, маршалит.

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СИНТЕЗ ИМПОРТОЗАМЕЩАЮЩЕГО СИНЕГО УЛЬТРАМАРИНА НА ОСНОВЕ МИНЕРАЛЬНОГО СЫРЬЯ ИЗ УНИКАЛЬНЫХ ОТЕЧЕСТВЕННЫХ МЕСТОРОЖДЕНИЙ

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Аннотация. Ультрамариновый пигмент, хотя и является широко востребованным дефицитным материалом, в Казахстане пока полноценно не производится, а огромные потребности удовлетворяются за счет импорта из других стран. Между тем в Государственных программах индустриально-инновационного развития Республики Казахстан, предусматривающих формирование конкурентоспособности, расширение номенклатуры и технологическое развитие отраслей обрабатывающей промышленности, неорганические минеральные пигменты в числе приоритетных материалов.

В целях обеспечения высокой экологичности, снижения себестоимости и оптимизации технологических процессов производства целесообразно использование доступных и распространенных чистых природных сырьевых материалов, однако, на сегодняшний день керамические пигменты чаще получают из затратных синтетических химических веществ, полученных с применением высокотемпературного синтеза. Поэтому изучение возможности синтеза силикатных пигментов на основе подобранных высокоэффективных видов минерального сырья и выявление закономерностей твердофазовых реакций при синтезе является актуальной задачей.

Основу научных исследований составляли минералого – петрографические и химические анализы сырьевых материалов, петрохимический расчет шихт ультрамарина и комплексные исследования полученных образцов.

Из числа отечественных полезных ископаемых выбраны оригинальные каолиновые и кремнеземистые виды сырья. Преимуществом предлагаемого синтеза является улучшение технологических качеств ультрамариновой шихты, обусловленного использованием высокосортного каолина и нового для данной технологии источника кремнезема – маршаллита, обладающего природной тонкодисперсностью, высокой реакционной способностью и обеспечивающего в полной мере протекание химических и твердофазовых реакций по всему объему шихты при более низких температурах.

Использование этих компонентов в шихте позволило получить яркий насыщенный пигмент синего цвета и снизить его себестоимость. Впервые продемонстрирована возможность получения ультрамарина синего цвета из местных природных видов минерального сырья.

Внедрение разработанной технологии синтеза ультрамаринового пигмента позволит решить проблему импортозамещения.

Ключевые слова: лазурит, ультрамарин, неорганический пигмент, минеральные сырьевые материалы, каолин, маршаллит

Introduction. Ultramarine remains the most popular blue inorganic pigment in the world to this day, the history of which begins with the use of natural lapis lazuli from the richest deposits in the territories of present-day Afghanistan and Tajikistan as a blue paint in ancient times. The lapis lazuli there, as a rock and a mineral, consisted almost half of lapis lazuli.

Lapis lazuli was once delivered to Europe and other parts of the Old World by merchants as a highly valued gemstone, but its waste during mining found a very wide profitable use there. For example, in Ancient Greece and the Roman Empire lapis lazuli enjoyed special fame as a raw material for the preparation of durable and beautiful blue paint, which gave magnificent colors in paintings by old masters (Belenkij, 1974:656; Betehtin, 2008:736).

The ideal formula of lapis lazuli is known, based on X-ray diffraction analysis data $Na_6\,Ca_2\,(Al_6\,Si_6\,O_{24})\,S_2$ I.Hassan (Chukanov, 2020:24) and a more general formula $(Na,Ca)_{7-8}(Si_6\,Al_6O_{24})(SO_{4,}\,S,Cl)_2\,\cdot H_2O$, proposed by V.A.Dir (Clark, 1978:6).

According to the crystal chemical classification of minerals by A.G.Betekhtin (Betehtin, 2008:736), lapis lazuli $Na_6Ca[AlSiO_4]_6\,(SO_4Cl,\,S)_2$ together with sodalite $Na_8[AlSiO_4]_6Cl_2$, nozean $Na_8[AlSiO_4]_6[SO_4]$ and gayuin $Na_6Ca[AlSiO_4]_6[SO_4]_2$ it is part of a single group from the silicate subclass with continuous three-dimensional tetrahedral frameworks $(Si,\,Al)O_4$ in crystal structures. All of them crystallize in cubic syngony.

As can be seen from the above, lapis lazuli differs in the content of sulfide sulfur in the anionic part of the formula. According to the researchers (Belenkij, 1974:656; Betehtin, 2008:736; Chukanov, 2020:24; Dir 1966:482), it is with this component that the peculiar azure-blue, greenish-blue and green colors of its rare rhombododecahedral crystals and formations, more often in the form of solid dense masses, are associated, which are not inherent in other silicates.

Scientific interest in the conditions of location, mineralogy, physical properties, chemical composition, radiography and crystal-crystallographic characteristics of lapis lazuli continues (Farsang,2023:10; Hassan, 1985:6; Kulinich 2000:251; Li 2011:6; Sapozhnikov 1992:3; Sapozhnikov, 2021:11; Sapozhnikov 2021:9; Tauson, 1998:17; Tauson, 2003:6; Taylor, 1967:17). In 2021, on the basis of research using a complex of modern instruments and methods for studying minerals and rocks, a group of scientists from the Russian Academy of Sciences A.N.Sapozhnikov, N.V.Chukanov et al. (Sapozhnikov, 2021:9) confirmed the status of lapis lazuli as an independent species. They proposed an idealized formula of lapis lazuli in the form of $Na_7Ca(Al_6Si_6O_{24})(SO_4)S_3^{-}\cdot H_2O$, where S_3^{-}, i.e. the trisulfide radical anion, according to scientists, is a blue chromophore.

The new formula of lapis lazuli explains the apparent excess of sulfur atoms that occurs when the composition is converted to Hassan's formula and determines the dark blue "velvet" color of the mineral by the presence of polysulfide ion S_3^{-} as a mineral-forming component.

The steady depletion and sometimes disappearance over time as a result of mining reserves of rich lapis lazuli deposits, and at the same time the growing demand for already high prices for natural raw materials led to the discovery in 1828 in France of a method for producing artificial lapis lazuli – ultramarine and the subsequent start of production.

Ultramarine is a synthetic aluminosilicate, a complete analog of lapis lazuli containing sodium and sulfur. It is characterized by a specific crystal lattice, which can be quite clearly depicted as grids of SiO_4 and AlO_4 tetrahedra (Fig. 1). These grids form closed internal cavities in which sodium and sulfur ions are placed.

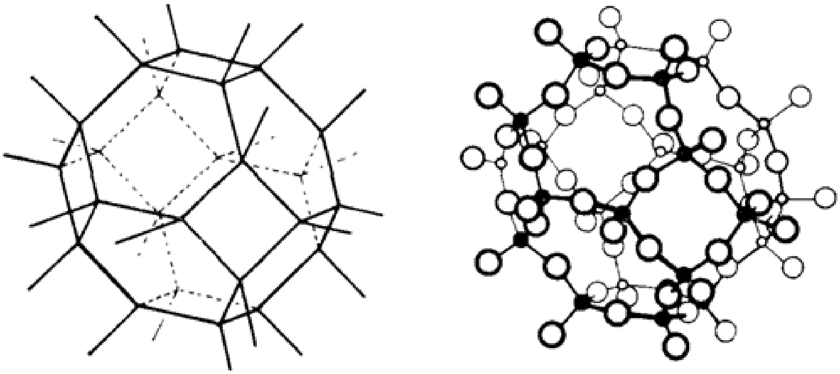

Figure 1 – Framework of SiO_4, tetrahedra underlying the structure of ultramarines. The Si atoms are located at the vertices of the polyhedron shown on the left. The silicon-oxygen framework spreads infinitely in three dimensions.

Even early X-ray studies of various ultramarines showed that all of them, regardless of color and composition, have the same crystal lattice, the same as natural lapis lazuli (Belenkij, 1974:656).

Many hypotheses have been proposed to explain the coloration of ultramarines. The most common hypothesis was that the coloration of ultramarines is due to the presence of colloidally dissolved sulfur in them. It has also been suggested that the color of ultramarines depends on the presence of certain groups of elements in the molecules, for example S_2O_3 or Al_2S_2. Currently, it can be considered established that the color of ultramarines is due to two factors: the structure of the crystal lattice and the nature of the bond in it between sodium and sulfur. However, the last of them remains insufficiently clarified to date.

Ultramarine, in addition to other areas, is indispensable in the production of ceramic, composite and glass products, in the coloring of ceramic granite tiles (Adyrbaev 2024:13), cement, building mixes, concrete and other materials for construction and technical purposes. Ultramarine is attractive for its aesthetics, bright color, high light and heat resistance, environmental friendliness and safety. With the rapid growth of housing and industrial construction, the demand for ultramarine is growing every year in the country. A situation is being created that can only be resolved by organizing its own production. On the way to solving the problem of creating a domestic import-substituting production, naturally, there will be questions of rational selection and provision of technology with affordable local technological natural types of mineral raw materials, instead of an expensive and not completely environmentally friendly chemical reagent.

Materials and basic methods. Ultramarine, as a rule, is synthesized on the basis of natural aluminosilicate raw materials – kaolin with the participation of silica, soda, sulfur and one of the traditional reducing agents by initiating solid-phase reactions of mineral formation at temperatures up to 800^0C in conditions of air access and without it. The number of components involved in the calculation mines is determined by the chemical formula of lapis lazuli and the molecular amounts of oxides and sulfur in the selected raw materials.

The objects of research are mineral raw materials for the production of ultramarine pigment charge and samples of ultramarine pigment.

In carrying out the work, the basis of scientific research was mineralogical, petrographic and chemical analyses of raw materials, petrochemical calculation of ultramarine charges based on selected natural and other components and comprehensive studies of the obtained samples. X-ray diffractometric analysis was performed on an upgraded automated diffractometer DRON-3 с $Cu_{K\alpha}$ – by radiation, β- filter. Diffractogram shooting conditions: U=35 кV; I=20 мA; shooting θ-2θ; detector 2 deg/min. X-ray phase analysis on a semi-quantitative basis was performed using diffractograms of powder samples using the method of equal attachments and artificial mixtures. The quantitative ratios of the crystalline phases were determined. The interpretation of diffractograms was carried out using data from the ICDD card file: PDF2 powder Diffraction data base (Powder Diffraction File) Release 2022 and diffractograms of minerals free of impurities. The thermal analysis of the charge was carried out on a synchronous thermal analyzer NETZSCHSTA 44 F3 Jupiter, differential thermogravimetric analysis of the charge was also carried out on a derivatograph Q-1500D, (DEMO).

Results. A series of experimental studies has been carried out to find optimal charge compositions and technological parameters for the synthesis of ultramarine pigment based on selected promising types of mineral raw materials and calculations of compositions. The features of the chemical and mineral compositions of raw materials, the effectiveness of physical-chemical processes during the heat treatment of ultramarine charge, as well as the qualitative and quantitative characteristics of the resulting material are studied.

The chemical compositions of the main phase-forming raw materials are shown in Table 1.

Table 1 - Chemical compositions of raw materials

Names of mineral raw materials, deposits	**SiO_2**	**Al_2O_3**	**CaO**	**MgO**	**TiO_2**	**Fe_2O_3**	**K_2O**
Kaolin, Souyznoe deposit	50.94	36.52	0.29	0.08	0.32	-	0.17
Marshallite, Mansurata deposit	95.8	4.06	-	-	-	0.14	-

For the synthesis of lapis lazuli (Fig. 2), the predominant component of ultramarine pigment, we used a soda-sulfur method based on heat treatment of charges from kaolin, silica, as well as soda ash, sulfur and a reducing agent – rosin.

Figure 2 – A sample of blue ultramarine synthesized on the basis of the developed charge (Table 2) on a polished plate of agate.

Kaolin for partial removal of hydrated water was pre-calcined in an oven at 800°C for 1-1.5 hours and then ground in a mortar until it completely passed through a sieve with mesh No.0085. Marshallite was also crushed until it completely passed through a sieve No.0085 and dried at a temperature of 100-110°C for one hour.

One of the optimal calculated compositions of experimental charges using marshallite as a silica component is shown in Table 2.

Table 2 – The composition of the charge

Names of the charge components, %				
Kaolin	Marshallite	Sulfur	Calcinated soda	Rosin
36.05	6.87	36.05	14.59	6.44

Taking into account the well-known achievements in the field of mineralogy, crystal chemistry, genesis and synthesis of lapis lazuli, we believe that in this generally accepted multicomponent ultramarine system, all components except silica are practically irreplaceable. Consequently, scientific research on optimizing the technology in question in terms of material balance should be conducted in the direction of establishing the most suitable natural or man-made silica.

In this paper, for the first time, an attempt was made to experimentally evaluate the reactivity in artificial solid-phase reactions of lapis lazuli formation of such common and easily accessible sources of silica as monomineral quartz sand, flask, quartzite, marshallite and technogenic microsilica. For these purposes, five independent charges were developed and compiled in the same way as with marshallite (Table 2).

The thermal curves were deciphered and mineralogically interpreted based on the results of dynamic heating of all five multicomponent compositions in the range from 20 to 1000°C. The survey results confirmed the predictions regarding the behavior of the components under heat treatment conditions. So, they are within 20~800°C left on differential thermoanalytical (DTA) and differential thermogravimetric (DTG) curves a series of peaks that are associated with endothermic and exothermic effects caused by the destruction of matter.

During heating, a weakly pronounced endothermic peak at 120°C, is observed on the DTA curve of the charge with marshallite, caused by the release of a fraction of organic matter from the rosin. In the region of the indicated temperature, the thermogravimetric (TG) curve formed a weight loss step (Δm1) corresponding to 2.5 mg. The thermal dissociation under consideration was more clearly manifested on the TG curve, which marked a change in the rate of atmospheric release of CO_{org}, in the form of an intense downward peak at 100°C (Figure 3).

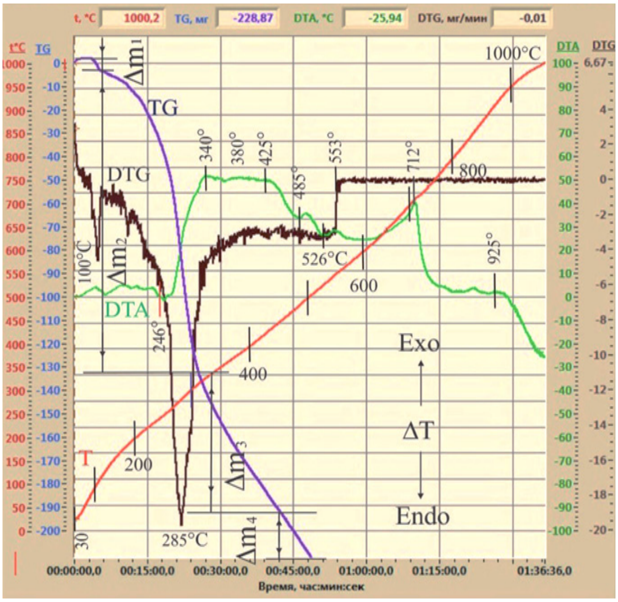

Figure 3. Thermogram of the charge, where marshallite is used as a silica component

Further decomposition of the system takes place in the range of 120-325°C, where the thermogravimetric curve records a weight loss (Δm2) of the sample equal to 129.5 mg. The DTG curve within these temperatures has a very significant peak in magnitude, corresponding to the rate of weight loss of thermally active components of the test sample. In turn, the DTA curve within the specified temperature range indicates an endothermic peak at 246°C, turning into an exothermic manifestation in the later stages (246-480°C) of decomposition of the charge. Thus, the development of the main peak on the DTG curve in the range of 120-340°C is caused by the joint combustion of lump sulfur and rosin in the charge, during which sulfur dioxide (SO_2) and carbon dioxide (CO_2) rush into the atmosphere, respectively. We emphasize that in the conditions of an experiment on the synthesis of lapis lazuli, the latter fall into the enclosed space of a small alund crucible. The combustion of sulfur and rosin leads to an influx of thermal energy into the system, which in the range of 246-526°C is recorded by the DTA curve as an exothermic manifestation in the charge. It was within these temperatures and saturation conditions of the SO_3 and CO_2 system that lapis lazuli was intensively formed in our experiments.

At the crest of the exothermic elevation of the DTA line (in the range 320-440°C), three maxima are traced at 340, 380 and 425°C. On the one hand, they were formed as a positive effect as a result of the formation of oncoming heat fluxes from the combustion of sulfur and rosin within the specified temperatures. On the other hand, the observed peaks on this curve are due to emissions of sulfur dioxide and carbon into the atmosphere, which caused endothermic manifestations. During the heating of the charge, the sulfur present in it, combining with atmospheric oxygen, is completely removed from the system in the form of SO_2, reducing the weight of the sample by 36.5%, i.e. by such a fraction as it corresponded to the mass of sulfur in the charge. Together with sulfur dioxide, carbon dioxide rushes into the atmosphere as a product of rosin combustion during the temperature increase. The reaction is accompanied by a decrease in the initial mass of the tested complex by 6.44%, i.e. rosin, like sulfur, practically burns completely.

Unlike these thermally active components of the charge, the destruction of soda ash proceeds with a partial loss of its mass. As sodium carbonate (Na_2CO_3), this substance decomposes into Na_2O and CO_2 when heated, with the release of carbon dioxide from the system. The amount of carbon dioxide formed in pure soda ash corresponds to 41.5%, therefore, in the charge, where Na_2CO_3 is 14.59%, its content is determined as follows: $\Delta m_{\text{soda ash}} = \left(\frac{41.5\% * 14.59\%}{100\%}\right) = 6.05\%$. The removal of this mass of carbon dioxide during the thermal degradation of sodium carbonate left an endothermic peak at 485°C on the DTA curve, and the indicated CO_2, emission on the TG line indicated weight loss ($\Delta m_{\text{soda ash}}$), according to the above expression.

Along with the mentioned effects, the charge under study had an endothermic peak on the DTA curve at 526°C associated with the removal of hydroxyl water from the kaolinite structure from the system. The participation of this clay mineral in the composition of the charge is also evidenced by the development of an exothermic bend in the area of 925°C on the specified curve, due to the destruction of the dehydrated structure of kaolinite and the formation of a new formation based on it – mullite $3Al_2O_3 \cdot 2SiO_2$, a classic phenomenon in ceramics technology. Our experiments on obtaining lapis lazuli mass are completed at 800^0C, i.e. far from reaching the temperature of mass mullitization of the system.

It is known that monomineral kaolinite, according to its stoichiometric formula, loses 26.36% of its weight during thermal dehydration. Based on this, a sample consisting of 36.5% kaolinite during firing will lose the following amount of its mass:

$\Delta \text{m kaolinite} = \left(\frac{36.5\% * 26.36\%}{100\%}\right) = 9.62\%$, or, in metric measurement, this value, according to the thermogravimetric data of the sample, will be - $\Delta \text{m kaolinite} = \left(\frac{228.9\text{мг} * 9.92\%}{100\%}\right) = 22.02 \text{ mg}$.

The thermal decomposition of the components of the specified sample is fixed on the differential thermogravimetric curve by four peaks. Two of them are pronounced at 100 and 285°C, and the other two peaks at temperatures of 425 and 526°C are significantly inferior in size and area to the indicated low-temperature manifestations.

According to semi-quantitative X-ray phase analysis, the concentration of lapis lazuli in the samples using marshallite is 82.0%. The radiograph also shows quartz and goethite lines - 16% and 1.9% (Table 3, Figure 4).

Table 3 - Results of semi-quantitative X-ray phase analysis of crystalline phases

Mineral	**Formula**	**Concentration, %**
Lapis lazuli	$(Na_7Ca)(Al_6Si_6O_{24})(SO_4)_{1.5}S_{0.6225}$	82.0
Quartz	SiO_2	16.0
Goethite	FeO(OH)	1.9

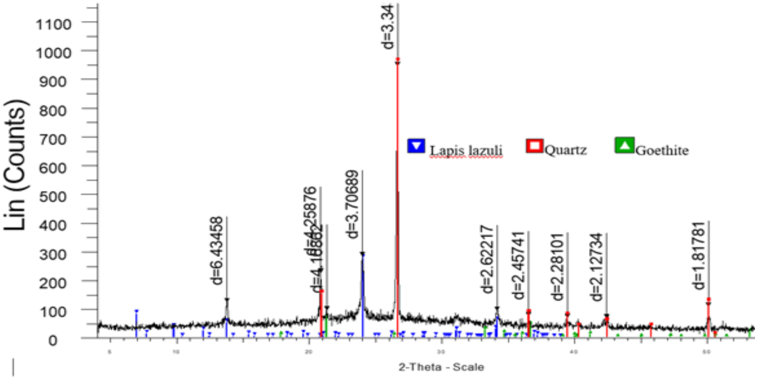

Figure 4 – X–ray of an ultramarine sample, where marshallite is used as a silica component

Discussion. Two centuries ago, in our opinion, close field geological observations, the study of mineralogical and petrographic features and the analysis of the genesis of lapis lazuli from the famous Afghan mines contributed to the successful synthesis of such a mysterious lapis lazuli and gave the right course to experiments. It was here that the special consequences of high-temperature physical and chemical processes of mineral formation were clearly manifested in connection with the introduction of an alkali-enriched magmatic melt into a sulfur-enriched carbonate stratum. The case in the geological history of the Earth is rare, but possible.

The productive thickness of the kaolin clays of the Soyuznoye deposit is composed of two varieties of kaolin – normal and alkaline. According to the degree of stability of the material composition and the scale of reserves, the deposit is estimated as unique (Kulinich, 2000:251). The normal kaolin deposit of the deposit consists of more than 85% kaolinite $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ and contains an average of more than 35% alumina, a component on the amount of which the technological properties of all types of clays depend. If we take into account that the theoretical content of Al_2O_3 in monomineral kaolinite is only 39.5%, then it is not difficult to imagine the value of the kaolin mineral raw materials selected by us – the most important component of the charge for the synthesis of ultramarine.

Due to the very favorable peculiarity of the chemical and mineralogical composition of the mineral, the peculiarities of the genetic aspects of the formation of the Soyuznoye deposit are of undoubted scientific interest. It is confined to the Mesozoic kaolin weathering crust formed on the contact of shales of the Middle Devonian age with the later Upper Mesozoic granite intrusive. In our opinion, the parent rock for such significant eluvial deposits of the deposit was not granites and shales in their pure form, but newly formed contact-metasomatic formations in the zone of their interaction. The latter, due to the high-temperature physical-chemical processes that took place, created Si and Al-enriched rocks with a less monolithic and fracture-resistant structure of the neoplasm than the surrounding granites and shales. Later, in the Mesozoic, continental weathering led to the formation of no less powerful acidic siallite eluvium in their place, composed mainly of aqueous aluminosilicates of a group of clay minerals. The Mesozoic kaolin weathering crust of the Soyuznoye deposit has no analogues in the country in terms of its main geological characteristics.

Conclusion. In the course of experimental work, a technology has been developed for obtaining the most lapis lazuli-enriched pigment in laboratory conditions with varying component composition of the charge and the temperature regime of processing.

Kaolin from the Soyuznoye deposit is quite suitable as the main component for the production of ultramarine pigment. As a siliceous additive, it is more effective to use marshallite, the birthplace of Mansurata, with a SiO_2 content of about 95.5%.

With the help of X-ray phase analysis, samples with high indicators of the amount of ultramarine were established. It turned out to be a compound with marshallite, where the amount of lapis lazuli reached 83%.

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