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Quality index control for building products made of natural facing stone

Volodymyr Shamrai[1*], Viktoriia Melnyk-Shamrai[1], Iryna Leonets[1], Valentyn Korobiichuk[1], Serhii Lutsenko[2]

[1] *Zhytomyr Polytechnic State University, Zhytomyr, Ukraine*
[2] *Kryvyi Rih National University, Kryvyi Rih, Ukraine*
**Corresponding author: e-mail korobiichykv@gmail.com*

Abstract

Purpose is to assess the influence of technological and natural factors on the decorative properties of natural facing stone to identify the regularities of changes in lightness and saturation of its surface.

Methods. To assess the effect of technological and natural factors on the decorative properties of natural facing stone, methods of digital processing of images and infrared spectroscopy have been applied. The methods make it possible to obtain the data on the influence of mineralogical and chemical composition on the decorative properties of natural stone and characterize the physicochemical processes that occur during the natural stone processing by different methods.

Findings. The regularities of changes in surface gloss of facing stone after its chemical treatment have been specified. It has been proved that all chemical impregnations increases stone gloss; the lower the initial indices of the natural stone surface gloss are, the greater stone changes are observed. In turn, that is caused by the fact that each type of natural stone has its own gloss limit. The regularities of lightness changes and surface saturation of natural facing stone after chemical treatment have been defined. They indicate that all agents reduce lightness and increase saturation of the natural stone surface (except Impregnation agent 3). According to the identified regularities, it is possible to control quality indices of the natural stone surface with simultaneous provision of uniform colour shade of a stone-faced building. The main problem arising during the study of surfaces of natural stone samples by means of infrared spectroscopy was inhomogeneity of its mineral-chemical composition over the sample area. As a result, various spectra have been obtained that are difficult to identify without the prepared reference samples. Complete infrared spectra of the natural stone surfaces of Pokostivskyi granodiorite and Bukivskyi gabbro. Both Pokostivskyi granodiorite and Bukivskyi gabbro have different infrared spectra within the analyzed range of wavelengths that can be explained by the difference in mineralogical composition of both natural stone types.

Originality is in identifying the regularities of changes in lightness and saturation of the natural facing stone surface after its chemical treatment.

Practical implications. The determined regularities of changes in lightness and saturation of the natural facing stone surface can help control the quality indices of the natural stone surface with the simultaneous provision of uniform colour shade of a stone-faced building.

Keywords: *decorative features of natural stone, gloss, saturation, lightness, natural facing stone, chemical impregnation*

1. Introduction

Natural stone always attracts attention of consumers despite the fact that in the era of high technologies, the market of building materials is saturated with a significant number of artificial substitutes. The advantage of natural stone is that the geological conditions in which it was formed gave it a complex of unique physical, technical, and decorative properties. Significant reserves of natural decorative and facing stone are concentrated on the territory of Ukraine, amounting to more than 500 mln m^3. Nowadays, about 300 deposits and occurrences of natural facing stone have been explored and studied in our country, of which approximately 164 are exploited permanently or temporarily and from which blocks of rocks that can be polished are mainly mined: granites, labradorites, gabbros, etc. Currently, the total production volume of blocks of natural stone in Ukraine is about 60-65%; mainly, those are high-strength rock blocks. In Ukraine, about 800 enterprises of various forms of ownership are engaged in the extraction and processing of natural facing stone; they mine annually more than 150000 m^3 of blocks and produce approximately 2.0-2.5 mln m^3 of facing slabs and stone products. It has been established that the existing deposits of decorative stone are extremely unevenly distributed across the territory of Ukraine [1]. The main part of the total number of deposits (about 80%) falls on five oblasts of Ukraine: Zhytomyr, Zakarpattia, Kirovohrad, Mykolaiv, and Rivne. The other 20 regions account for only 20%. Zhytomyr Oblast is a leader in the field of stone mining. About 35% of decorative stone from the total reserves in Ukraine is located there.

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Zhytomyr Oblast is characterized by a large number of outcrops of crystalline rocks on the day surface and a low capacity of overburden, which became a prerequisite for the creation of a powerful mineral and raw material base of building and facing stone in this region. In this regard, Zhytomyr Oblast is peculiar for the significant volumes of mining and processing of granites, granodiorites, gabbros, labradorites, porphyrites, granitogneisses and other high-strength crystalline rocks. The mineral and raw material potential is represented by more than 220 deposits of various minerals. Of the 160 deposits of decorative stone developed permanently or temporarily in Ukraine and taken into account by the State balance of mineral reserves, 70 are located in Zhytomyr Oblast, which volume of deposits is 126 mln m^3 or 40% of state reserves. Moreover, as for the number of varieties of high-strength decorative stone, Zhytomyr region accounts for 60% of the stone. In terms of 600 stone-working enterprises of Ukraine, 220 enterprises are located in Zhytomyr Oblast, which together produce about 400000 m^2 of stone products. Zhytomyr Oblast exports about 1.5 thousand m^3 of block raw material annually. There are 20% of Ukraine's reserves of crushed building raw materials within the Oblast; the reserves are the basis for the founded significant production facilities [2].

The decorativeness of the stone in combination with the performance characteristics of the quality is a property that determines a stone value, i.e. the value of the natural stone, on which basis it is possible to determine the limits of its rational use. To identify the decorative properties, stability of the stone colour is of great importance, but it can vary greatly [3]. When facing with natural stone, differences in the colour tone of different samples can be observed, which is due to the mineralogical and chemical composition of the stone. When facing buildings with natural stone, especially when such works have a large area, the problem of selecting single-tone slabs arises. When restoring monuments and architectural objects from natural stone, significant problems arise with the choice of natural stone. The problem is that most of the deposits from which natural stone was extracted either ceased to exist or began to develop other levels of natural stone, which decorative indicators differ significantly. It is also worth remembering that with long-term use of natural stone products under the influence of aggressive environmental factors, the stone surface loses gradually its original decorative properties. To increase decorative indicators, as well as to correct them, you can use chemical agents, which range today is rather wide. The increase or decrease of various indicators of decorativeness requires analysis, determination, and selection of an appropriate chemical agent [4].

Such scientists as Ye. Fedorov, V.I. Vernadskyi, O.E. Fersman, E.K. Lazarenko dealt with the analysis of colour of rocks and certain minerals for petrographic study of rocks while deposit prospecting; they considered shades of colour mainly as the signs for finding ore deposits. Paper [5] is devoted to the study of textural and colour characteristics of facing rocks.

V.V. Indutnyi and O.R. Marukhin studied and determined accurately the colour of minerals and rocks; they proposed to use standard colorimetric parameters to assess the stone colour – lightness, saturation of the main colour tone, wavelength of the main (dominant) colour tone. A.O. Kryvoruchko also analyzed the problem proposing to apply modern computer technologies to determine objectively the colour, its saturation and brightness using specific quantitative indicators. The study of the determination of decorative indicators is carried out by the organoleptic method, which is subjective. There are also objective methods for assessing decorativeness, with the help of which standard colorimetric parameters can be determined using such information as brightness, saturation of the main colour tone, wavelength of the main (dominant) colour tone, and computer technologies. Papers [6]-[10] proposed a method excluding subjective determination of the decorative properties of rocks. According to [11], roughness of the stone during polishing can affect the stone surface colour. The paper considers the impact of not only polishing but also the impact of an acidic environment on limestone and marble, which increases stone surface roughness to a certain extent, but these changes occur heterogeneously. At the same time, unlike mechanical polishing, the colour of the stone surface after exposure to an acidic environment depends not only on the stone surface roughness but also on the mineral particles making up the rock.

In paper [8], the effect of high temperatures on the change in stone properties was investigated using digital image processing. As the temperature rises, the stone becomes lighter. Using the method of black and white digital image processing, the effect of weathering and action of salts on the stone was studied; illuminated areas on its surface were revealed [7]. It was also proven in [8] that under the influence of an aggressive environment, colour saturation is lost, the stone becomes lighter and requires further restoration work. The analysis of literary sources shows that many studies are related to the study of features of the stone microtexture, the influence of an aggressive environment. However, the change of colour features and regulation of such features during the processing of natural stone were not examined.

Mass distribution and application of information and computer technologies did not bypass the stone mining and processing industry. Papers [12], [13] show the possibility of entering the image of a surface of industrial samples of facing stone into the computing environment of modern computers. That makes it possible to use full potential of computational methods of digital processing of video images to solve practical problems of the mining industry. Such studies and measurements are usually performed by observing the surface of selected natural stone samples. Classical methods of surface research using a laboratory microscope have a number of disadvantages associated with the use of manual labour during the measurements and processing of their results. Therefore, to determine mechanical properties of natural stone, it is necessary to use information and computer technologies for processing video images.

In addition, many studies are related to the study of the influence of various atmospheric and aggressive factors [14]-[19] and development of methods for determining colour coordinates but little attention is paid to the study of the influence of chemical treatment on the natural stone gloss and lightness. Chemical impregnations, which are widely distributed on the market of Ukraine, have not been studied enough for Ukrainian natural stone. Thus, their effect on the indicators of gloss, saturation, and lightness of various types of natural stone and the subsequent effect on decorative indicators should be studied as well as the issue of the effectiveness of using different chemicals on different rock types.

Therefore, the purpose of the paper is to assess the influence of technological and natural factors on the decorative properties of natural facing stone.

2. Materials and research methods

The research was carried out in terms of polished stone samples from different types of natural facing stone measuring 200×200×20; their mineral composition and appearance are shown in Table 1. Samples of the most common types of natural stone in Ukraine were selected from high-strength stone of the following deposits: Pokostivske granodiorite deposit, Bukivske gabbro deposit, Golovynske labradorite deposit, Mezhyrichynske granite deposit, Kapustynske granite deposit, Zhadkivske granite deposit, and Leznykivske granite deposit.

For the mechanical processing of natural stone, diamond fickerts were used; their characteristics are represented in Table 2. The number of passes is also indicated in numbers. Such a scheme of diamond tool using makes it possible to get a high-quality stone surface and give it maximum gloss [20].

Table 1. Mineralogical composition of the used types of natural facing stone

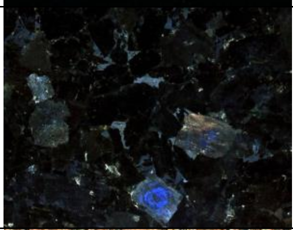
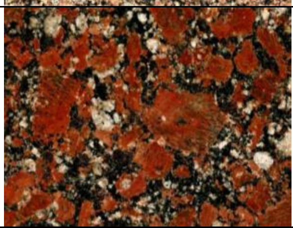
Stone type	Appearance of the natural facing stone samples	Mineral content, %					
		Microcline	Plagioclase	Quartz	Biotite	Pyroxene	Other
Pokostivskyi granodiorite (Grey Ukraine)		15-30	35-55	10-25	5-15	–	1
Bukivskyi gabbro (Galant)		2-9	57-72	5	3	25-32	0-14
Golovynskyi labradorite (Black Sea)		3	85	7	1	3	1
Mezhyrichynskyi granite (Rosso Pink)		60	20	15	5	–	1
Kapustynskyi granite (Rosso Santiago)		50	24	18	7	–	1
Zhadkivskyi granite (Rosa Raveno)		60	20	15	5	–	–
Leznykivskyi granite (Ukrainian Red)		80	–	15	5	–	–

Table 2. Characteristics of a diamond tool for the natural stone processing

Number of passes	Tool numbers	Graininess, µm
	No 00 (diamond)	710/600
1	No. 24	500/400
1	No. 240	200/160
4	No. 400	80/63
2	No. 600	60/40
2	No. 800	40/28
2	No. 1200	28/20
2	No. 1500	20/14
2	No. 2000	10/7
2	No. 3000	5/3
1	Polishing	1/0

Following tools were used for chemical treatment:

1) impregnation agent 1 (pH = 5.36) is a varnish-based impregnation agent that gives the surface the effect of wet stone and is used to treat surfaces of all-type natural stones to protect them against moisture, oil, and grease, and enhance colour;

2) impregnation agent 2 (pH = 3.98) is a transparent crystallizer based on a silicate solution with wax; it is used to improve the gloss and colour saturation of all types of natural facing stone;

3) impregnation agent 3 (pH = 9.12) is a black crystallizer for the products made of natural stone (black shades) granite, gabbro, and labradorite. The product penetrates deeply and closes pores, microcracks, protecting the stone from damage. Strengthens and enriches the stone colour and gives the stone a gentle gloss;

4) impregnation agent 4 (pH = 7.45) is a red crystallizer based on a solution of silicates with red pigments for natural stone products (red shades). It is used to saturate colours, emphasize the texture, and add gloss to the stone.

Stone tiles were processed with a diamond tool on a flat grinding machine. Next, the samples are dried, the gloss is measured using a portable gloss meter, and the treated surface is scanned. The resulting image is then calibrated and processed in the Mdistones software. For each received image of the polished surfaces of the samples, the average indicators of colour coordinates in the LAB system are determined (Fig. 1). The determined colour values are converted to the HSV colour system to identify saturation.

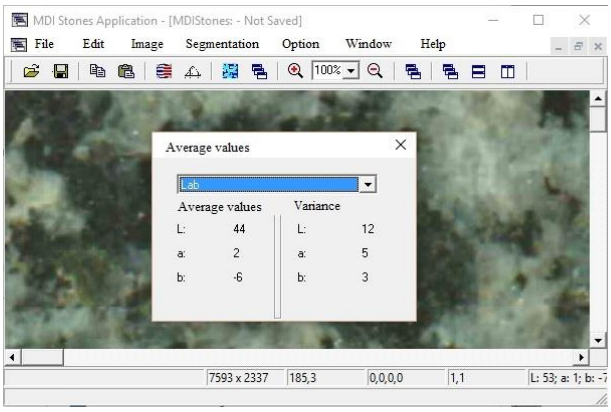


Figure 1. Example of determining colour coordinates in the Lab system using Mdistones

To specify the effect of chemical treatment, chemical impregnation is applied to the treated surface of the natural facing stone with a diamond tool. Further, operations are carried out according to the research methodology for chemically treated samples.

Gloss is the ability of a surface to reflect light without scattering. To ensure reliably high quality, it is necessary to evaluate the appearance of the coating according to objective criteria that can be measured. An accurate description of the coating appearance allows controlling the quality of the coating and improving it by optimizing the production process. Gloss measurement helps assess homogeneity and uniformity of the coating, control wear and deterioration of the coating, and optimize technological processes. As the degree of gloss increases, the colour of the coating becomes richer and more intense. The lower the degree of gloss is, the less intense and saturated the colour looks. The higher the surface gloss is and the harder the surface is, the easier it is to clean and the better its wear resistance is.

The measurement of the reflectivity of the polished surface is based on the comparison of indicators obtained from the gloss meter with the indicator of the reference surface. Depending on the value of this indicator, facing stones are divided into four categories (Table 3).

Table 3. Stone classification according to the reflectivity after polishing

Category by reflective ability	Rock type	Reflectivity after polishing (as the benchmark percentage)
I (excellent)	Marbles and some types of granites	85-100
II (good)	Granites and some types of marbleized limestones	75-85
III (average)	Dense basalts, limestones, marbled limestones, and weathered granites	35-75
IV (bad)	Porous basalts and limestones, partially marbleized limestones with extraneous inclusions	< 35

Currently, new generation gloss meters that meet international standards are widely used; they determine surface gloss in relative values – as the ratio of intensity of light reflected specularly to the intensity of light reflected diffusely. The use of such gloss meters makes it possible to avoid errors that arise due to the presence of light absorbed by the material. Model “BF-5” (Ukr. БФ-5) is shown in Figure 2. In addition to the above, it has such advantages as compactness and mobility. The gloss meter is powered by batteries and has a gloss display scale. It is also characterized by a small absolute error in gloss measurement (± 2).

Figure 2. Gloss metre “BF-5”

This gloss meter is designed to measure gloss at illumination angles of 20°/20°, 45°/45°, 60°/60°, and 85°/85° of directed light flux of various surfaces within the visible spectrum range. In addition to the reflectivity of rock surface, it is also possible to determine the level of its whiteness. The essence of gloss determination is to compare reflectivity of the examined surface with the polished surface of a black standard when determining gloss, and the white one while defining whiteness. The measurement results are expressed in the international gloss units – GU, corresponding to the standard units when measured with a gloss meter.

The method of determining the natural facing stone gloss involves the use of a measuring instrument (gloss meter), which is located at various points of the measuring surface of the samples, and collection of data used for further research.

The research methodology relies on following principle:

1) selection of the processed rock samples with a size of at least 10×10 cm;

2) samples are cleaned of dust, dirt, and other substances that can contaminate the surface;

3) calibration of the device according to standard 91 GU (Ukr. ГУ);

4) gloss is measured at different points of the processed rock samples;

5) determination of the average gloss indicators and their further use in studies.

3. Results and discussion

A characteristic feature of natural facing stone is the variability of its decorative properties. A change in the decorative properties of natural stone can be observed not only within one deposit but also even within one section of a quarry. Consequently, when a large batch of natural stone facing products is manufactured, there is a problem with the selection of single-toned natural stone slabs.

According to the methodology, a change in the gloss indicators of the natural stone surface after chemical treatment was identified (Fig. 3).

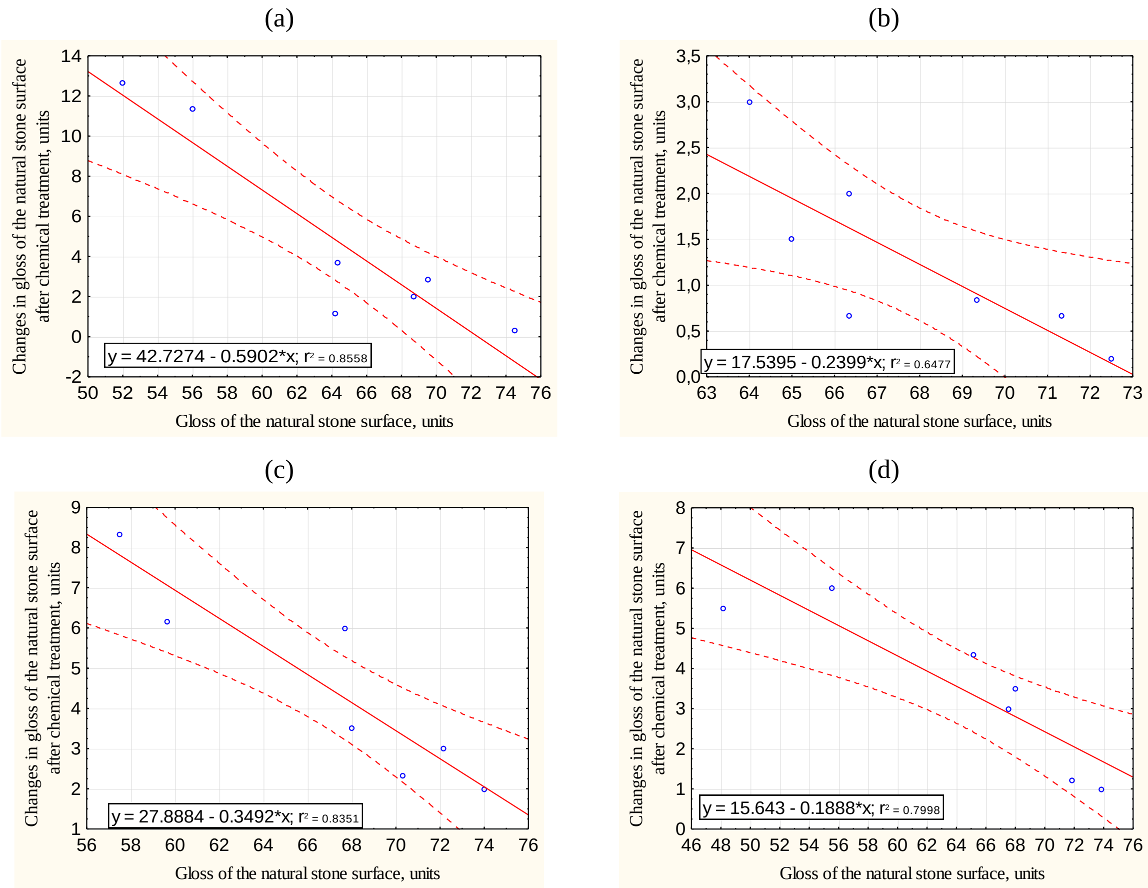


Figure 3. Changes in gloss after the treatment of polished stone textures with the chemical impregnation agents: (a) impregnation agent 1; (b) impregnation agent 2; (c) impregnation agent 3; (d) impregnation agent 4

According to Figure 3, all chemical impregnations increase the gloss over natural stone. At the same time, the greatest change in gloss is observed after the treatment with chemical Impregnation agent No 1. According to the established regularities of changes in the natural stone surface gloss, the lower the initial gloss of the natural stone surface is, the greater its change is after its chemical treatment. In turn, it is explained by the fact that each type of natural stone has its own limit gloss, which change can occur within small limits.

Like the gloss, the lightness of a natural stone surface is one of the characteristics of its decorativeness. Therefore, we determined certain change in brightness of samples with a polished surface after chemical treatment (Fig. 4).

According to Figure 4, when the impregnation agent is applied to the sample surface, the brightness decrease is observed, which corresponds to negative values on the *Y* scale. The largest decrease in brightness is shown by the samples with great initial brightness of the surface.

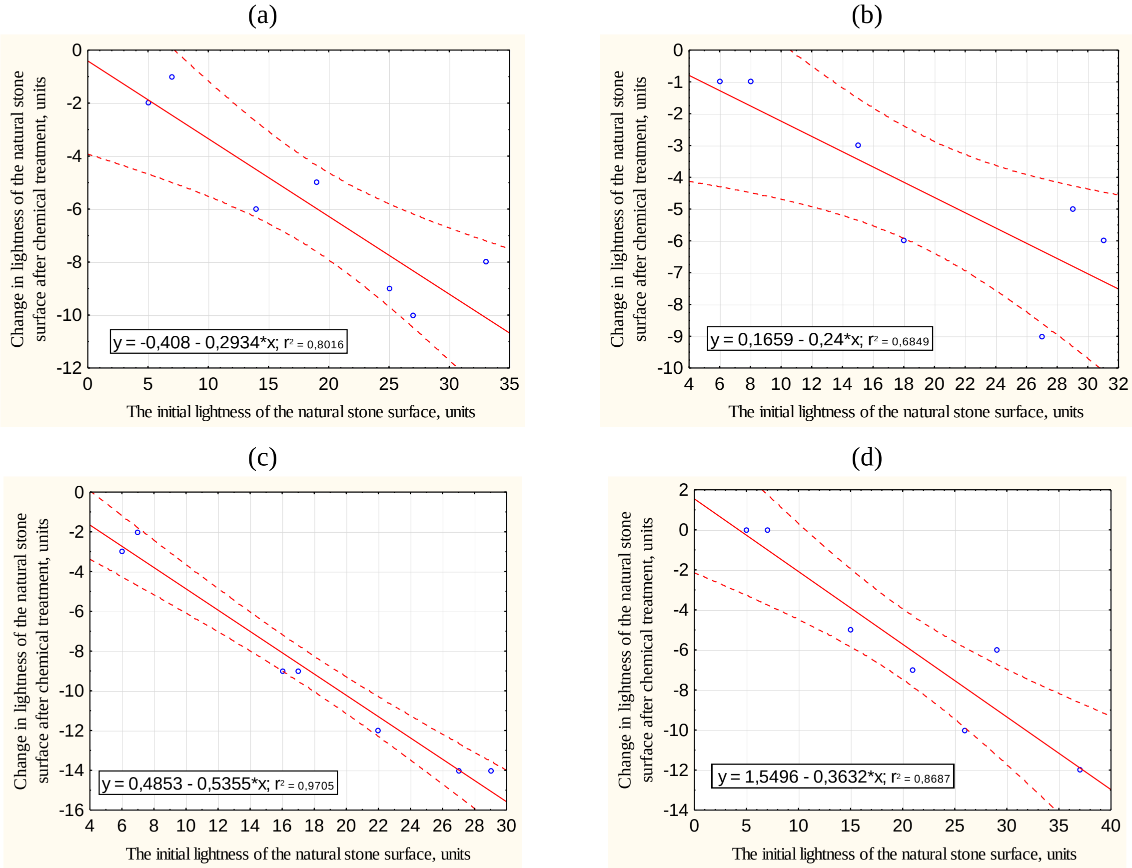


***Figure 4.** Change in lightness values after the treatment with a chemical impregnation agent (polished texture): (a) impregnation agent 1; (b) impregnation agent 2; (c) impregnation agent 3; (d) impregnation agent 4*

For example, if the initial lightness of the surface of a natural stone is 22 units, and a change in lightness after treatment with a chemical impregnation agent is -12, then the surface lightness of the sample will be 22 – 12 = 10 units (Fig. 5c; point $x = 22$; $y = -12$).

The next main feature of the decorativeness of the natural stone under consideration is saturation. For a natural stone with a chromatic colour, this feature is more significant than for the achromatic ones. Accordingly, it was decided to determine a change in saturation of the natural stone surface (Fig. 5).

Figure 5 demonstrates that impregnation agent 3 reduces the natural stone saturation due to the presence of black impurities that colour the stone. Accordingly, its use is not recommended for the light-coloured types and the ones with chromatic colouring; however, it can be used for the types, which colour is close to black. Impregnation agents 1, 2, 4 increase the natural stone saturation; they are recommended to be used for most types of natural stone. As with the determination of lightness, the saturation of natural stone after appropriate chemical treatment can be determined according to the established patterns shown in Figure 5.

Infrared spectroscopy is mainly used for quantitative and qualitative analysis of the composition of various substances. There are many obstacles to surface infrared analysis because the properties and conditions of the samples to be tested must be the same. The main problem that arose during the study of the surface of natural stone samples was the heterogeneity of its mineral and chemical composition, spreading over the sample area. As a result, various spectra were obtained, which were difficult to identify without previously prepared control samples. The complete infrared spectra of the natural stone surface of Pokostivkyi granodiorite and Bukivskyi gabbro are shown in Figure 6.

Many peaks within the range from 1400 to 300 cm^{-1} were observed, which makes it possible to identify certain differences between the natural stones and determine the efficiency of natural stone processing. For this reason, this range of wavelengths was investigated in this work (Fig. 7).

As we can see from Figure 7, Pokostivskyi granodiorite (Grey Ukraine) and Bukivskyi gabbro (Galant) have different infrared spectra in the studied wavelength range, which can be explained by the difference in the mineralogical composition of both natural stone types. Spectra of Pokostivskyi granodiorite (Grey Ukraine) have more peaks than Bukivskyi gabbro (Galant) as Pokostivskyi granodiorite (Grey Ukraine) contains more minerals in its composition. Bukivskyi gabbro (Galant) consists mainly of plagioclase and pyroxene, while Pokostivskyi granodiorite (Grey Ukraine) consists of microcline, plagioclase, quartz, and biotite [3]. In addition, natural stones within the same geological zone usually have common minerals. Both investigated natural stones have one common mineral – plagioclase; while analyzing the spectra of both materials the same wavelengths belonging to plagioclase were identified (Table 4) [21].

However, there are also some differences in the spectra of these stone types, characterizing their minerals. Pokostivskyi granodiorite (Grey Ukraine) has following clear peaks: 1330, 1145, 1089, 813, 746, 671, 649, 636, 563, 522, and 405 cm^{-1}, which corresponds to microcline (1330, 1145, 649, 563, and 522), quartz minerals (1089, 813, 671, and 405), and biotite (746, 636, and 405). Bukivskyi gabbro (Galant) has the peaks of 1263, 981, 960, 935, 921, 663, 489, 476, and 453 cm^{-1}, which corresponds to the mineral of pyroxene [20].

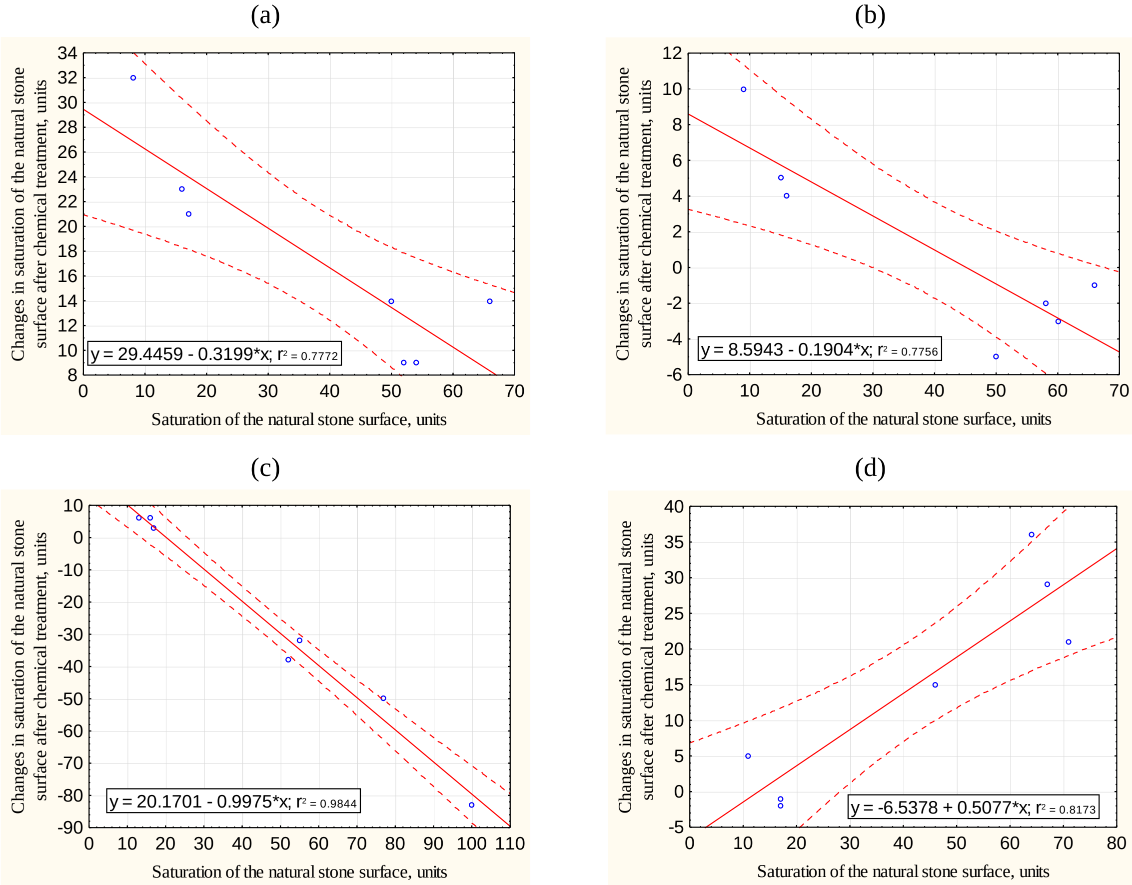


Figure 5. Change in saturation values after the treatment with a chemical impregnation agent (polished texture): (a) impregnation agent 1; (b) impregnation agent 2; (c) impregnation agent 3; (d) impregnation agent 4

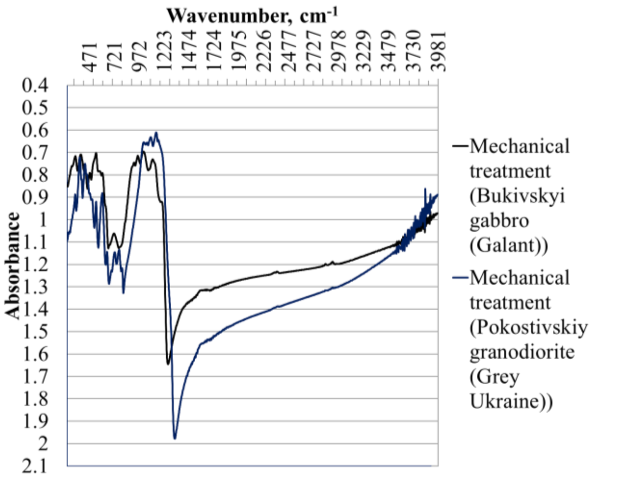


Figure 6. Full IR spectra of the natural stone surface of Pokostivskyi granodiorite (Grey Ukraine) and Bukivskyi gabbro (Galant)

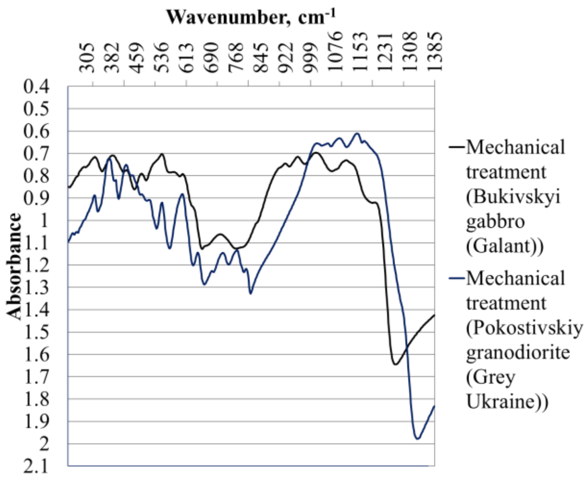


Figure 7. Range of wavelengths from 1400 to 300 cm^{-1} of IR spectra of the natural stone surface of Pokostivskyi granodiorite (Grey Ukraine) and Bukivskyi gabbro (Galant)

Table 4. Description of the spectra of natural stone corresponding to the common mineral plagioclase

Wavelength, cm^{-1}	
Pokostivskyi granodiorite (Grey Ukraine)	Bukivskyi gabbro (Galant)
1112	1110
1064	1066
1020	1016
771	769
727	721
603	603
540	540
428	430

The possibility of identifying gabbro minerals was investigated by Rost et al. [22]. Considering the conditions of sample preparation, which involves polishing the natural stone surface, the authors found that the stone surface roughness affects the infrared spectra. When the surface is treated with chemical impregnations, absorbance can be affected by a change in the angle of IR ray reflection due to following two factors (Fig. 8):

1. Cavity effect. This effect depends on the quality of the natural stone surface polishing (surface roughness). If the IR ray enters the resonator, the absorbance increases. When the surface of the stone is processed with a chemical reagent, the cavities are filled, and the absorbance decreases.

2. Volume scattering. Scattering occurs due to the IR ray passage through a transparent layer of chemical impregnation, which changes the angle of reflection.

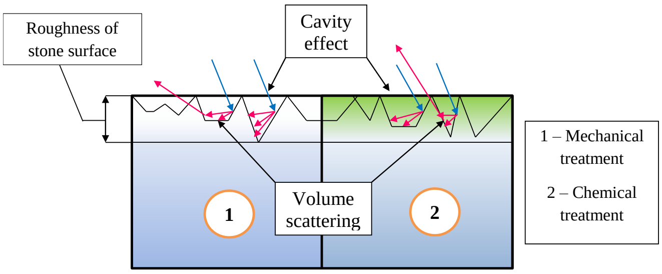


Figure 8. Factors influencing the infrared spectra absorbance

After the chemical treatments, infrared spectroscopy of the surface of Pokostivskyi granodiorite and Bukivskyi gabbro was carried out (Fig. 9). For each type of stone (Grey Ukraine or Galant), the change in absorbance is more or less depending on the means of impregnation. A decrease in the IR spectra absorbance was detected after four chemical treatments, with the exception of impregnation 4 in Bukivskyi gabbro [23], [24]. Changes in the absorbance intensity after these treatments are the result of the two factors mentioned. No formation of new spectrum peaks was observed without nerves. This indicates that chemical treatment does not lead to the formation of new substances. It forms a nanofilm that fills the micro irregularities of the natural stone surface.

It is important to emphasize that there is no chemical interaction of the four impregnation agents with the two natural rocks, which guarantees their chemical stability. Moreover, the pore coating guarantees greater surface strength.

As a result of the study, it was found that the areas of dark and light minerals affect directly the lightness and saturation of the stone. The lightness of the stone surface increases along with the increasing areas of light minerals, which is also confirmed in paper [4].

In [16]-[18], the effect of surface coatings of natural stone on physical properties, including colour, was considered in order to protect natural stone from atmospheric influences. These studies are somewhat similar; however, for different types of natural stone, it is impossible to use the same means without prior study as chemical coatings can have the opposite effect. In particular, it can accelerate significantly the natural stone weathering and change significantly the texture (including colour) [19], [25]. Therefore, the change in both surface colour of natural stone and its spectra was investigated in the paper to identify chemical interaction between the chemical treatment and surface of natural stones. As in [22], a change in absorbance depends on the porosity and roughness of the natural stone surface.

In order to evaluate the effectiveness of chemical impregnation agents, it is necessary to conduct additional stu-dies concerning the influence of the surrounding aggressive environment (temperature changes, humidity effects, ultra-violet radiation, etc.) on the decorative properties of natural stone. The studies should involve digital image processing and infrared spectroscopy, which will make it possible to determine the presence of weathering products and traces of weathering on the natural facing stone surface.

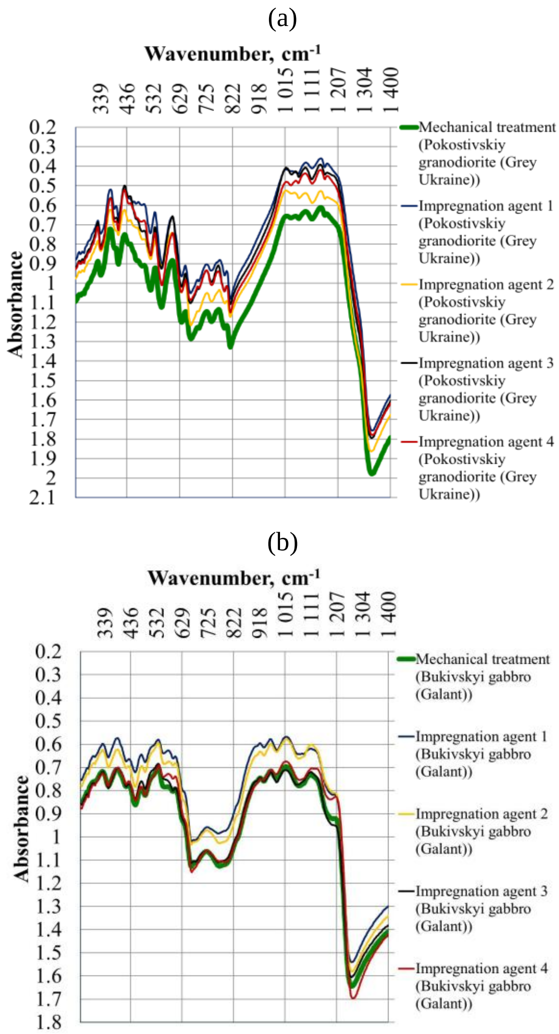


Figure 9. Changes in absorbance by chemical impregnations for different types of natural stone: (a) Pokostivskyi granodiorite (Grey Ukraine); (b) Bukivskyi gabbro (Galant) after chemical treatment

4. Conclusions

Using the methods of digital image processing and infrared spectroscopy, the physicochemical bases of natural stone processing have been identified; it allows identifying the following.

All chemical impregnations increase the natural stone surface gloss. At the same time, the greatest change in gloss is observed after the treatment with Impregnation agent 1. According to the defined patterns of changes in the natural stone surface gloss, the lower the initial gloss of the natural stone surface is, the greater its change after the chemical treatment is. This, in turn, is explained by the fact that each type of natural stone has its own limit gloss, which change can occur within small limits.

After applying the product to the sample surfaces, the decreasing lightness is observed. Samples with the large initial surface brightness show the greatest decrease in brightness.

Impregnation agent 3 reduces the natural stone saturation due to the available black impurities colouring the stone. Accordingly, its use is not recommended for the light-coloured types and the types with chromatic colouring. However, it can be used for the types that have a colour close to black. Impregnation agents 1, 2, and 4 increase the natural stone saturation; they are recommended to be used for most types of natural stone.

Absorbance changes at the IR spectra peaks for natural stone samples after chemical treatment were more intense in the Grey Ukraine sample since the colour spectrum in this sample is lighter. Chemical interaction of the impregnation agents and the natural rock is minimal. It does not affect the natural rock chemically as the infrared spectrum shows the same peaks in the treated sample as in the untreated one.

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Керування показниками якості будівельних виробів із природного облицювального каменю

В. Шамрай, В. Мельник-Шамрай, І. Леонець, В. Коробійчук, С. Луценко

Мета. Оцінка впливу технологічних і природних чинників на декоративні властивості природного облицювального каменю для встановлених закономірностей зміни світлоти та насиченості його поверхні.

Методика. Для оцінки впливу технологічних і природних чинників на декоративні властивості природного облицювального каменю було використано методи цифрової обробки зображень та інфрачервоної спектроскопії, які дозволяють отримати інформацію про вплив мінералогічного і хімічного складу на декоративні властивості природного каменю та охарактеризувати фізико-хімічні процеси, які протікають при обробці природного каменю різними методами.

Результати. Встановлено закономірності зміни поверхневого блиску природного облицювального каменю після хімічної обробки. Доведено, що всі хімічні просочення підвищують блиск, і чим нижчі початкові показники блиску поверхні натурального каменю, тим більше змінюється блиск. Це, в свою чергу, викликано тим, що кожен вид природного каменю має свою межу блиску. Встановлено закономірності зміни світлоти та насиченості поверхні природного облицювального каменю після хімічної обробки. Вони показують, що всі агенти зменшують світлоту і підвищують насиченість (за винятком Impregnation agent 3) поверхні натурального каменю. Відповідно до встановлених закономірностей, можна контролювати якісні показники поверхні природного каменю, і при цьому забезпечити рівномірний колірний тон облицьованої каменем будівлі. Основною проблемою, яка виникла під час дослідження поверхні зразків природного каменю інфрачервоною спектроскопією була неоднорідність його мінерально-хімічного складу, яка розповсюджена по площі зразка. У результаті були отримані різноманітні спектри, які важ-ко було ідентифікувати без попередньо підготовлених контрольних зразків. Отримано повні інфрачервоні спектри поверхні природного каменю Покостівського гранодіориту та Буківського габро. Покостівський гранодіорит і Буківський габро мають різні інфрачервоні спектри в досліджуваному діапазоні довжин хвиль, що можна пояснити різницею в мінералогічному складі обох природних каменів.

Наукова новизна полягає у встановленні закономірностей зміни світлоти та насиченості поверхні природного облицювального каменю після хімічної обробки.

Практична значимість. За допомогою встановлених закономірностей зміни світлоти та насиченості поверхні природного облицювального каменю можна контролювати якісні показники поверхні природного каменю, і при цьому забезпечити рівномірний колірний тон облицьованої каменем будівлі.

Ключові слова: *декоративність природного каменю, блиск, насиченість, світлота, природний облицювальний камінь, хімічне просочення*