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EVALUATION OF OPTICAL PARAMETERS OF NATURAL STONE SURFACE USING INFRARED SPECTROSCOPY

Preservation and improvement of quality indicators of any product is an urgent scientific and practical problem for current production, including products from a natural facing stone. There are no similar deposits of natural facing stone in the world. Each of them is unique in its own way. However, most natural stone deposits are characterized by natural variability of quality indicators. First of all, the difference in color tone appears after stone processing.

You can use chemical impregnations, as well as various mechanical tools for grinding and polishing natural stone to align the natural stone hue.

With regard to chemical treatment, most research is devoted to study the microstructure, corrosion resistance, development of new chemical agents for the treatment and protection of natural stone surfaces, mainly carbonate composition.

Many commercial brands of chemical impregnating means do not inform about the chemical composition of these products and do not describe the effects of interaction with certain minerals and chemical elements that may occur on the treated stone surface. This treatment can result in corrosive processes that affect the natural stone stability and decorativeness. The use of infrared analysis in the study of samples treated in different ways, allows to avoid inefficient use of chemical means for impregnating the natural stone surface treatment. Also, the use of this method allows to characterize the action of certain types of chemical impregnating agents, to find the content of the main components and to obtain detailed recommendations for their use for certain types of natural stone. However, the main problem with the use of infrared analysis of the natural stone surface is to reduce the reliability of the data obtained, because the study of natural stone containing several major minerals, obtained different values of peak wavelengths associated with the mineral.

Infrared spectroscopy (IR) was performed to determine the structure of natural stone samples with different treatments. The IR spectra of natural stone samples were measured using a Bruter Tensor 27 FTIR spectrometer, scanning them in the range of 4000 to 250 cm− 1, using KBr in drift mode to study the change in natural stone samples after chemical and mechanical processing.

Surface reflection can be divided into two finite elements: mirror reflection of a smooth surface with high opacity and diffuse reflection of a rough surface with constant opacity. In the case of specular reflection, the surface behaves specularly, and the angle of incidence is equal to the angle of reflection, which leads to coplanar reflection. In diffuse reflection, the rays are reflected in many directions, regardless of the angle of incident radiation. Therefore, the reflected energy is propagated to a large number of light rays, which can, depending on the measurement method, reduce the absolute reflection of the signal. Most surfaces do not reflect the actual mirror and diffuse reflection, but the sum of the two finite exponents.

Volumetric scattering occurs when the surface contains significant amounts of hyperfine particles (1–20 microns), which introduce the transmission of incident rays through compressed particles. As a result, energy is lost due to partial absorption of the signal. This affects the spectral signature, which leads to changes in the shape of the spectrum. Spectral characteristics shift to longer wavelengths and spectral loss of contrast or even to spectral signatures inversion.

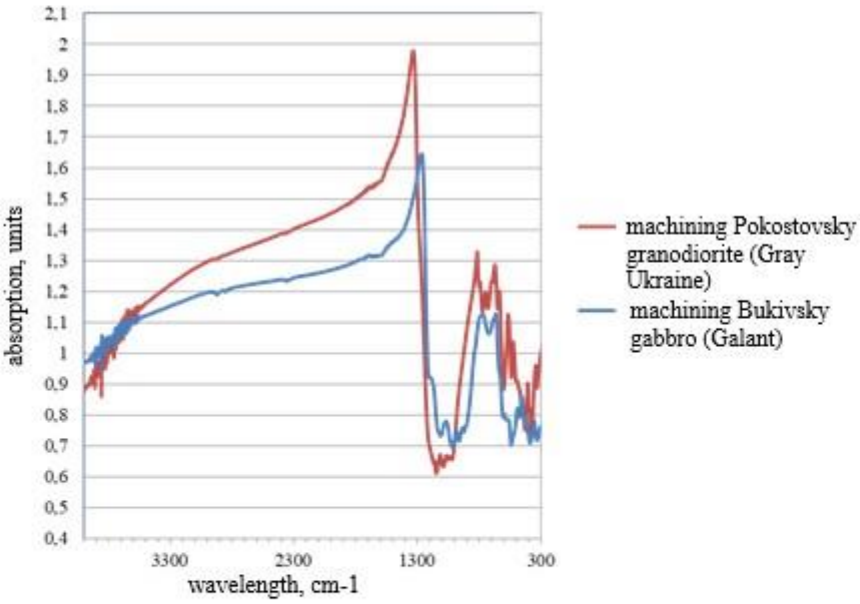
Surface cavities can capture and absorb incident rays, reducing reflection and the accompanying spectral contrast, a phenomenon known as the cavity effect. The relationship between the number of cavities on the surface and the spectral contrast is approximately linear. Factors influencing the decrease in spectral contrast are the shape of the cavity, the area of the cavity, the area of the inlet and the diffuse or mirror reflectivity of the wall of the cavity. As a rule, the higher the ratio of the depth of the cavity to the width of the entrance, the greater the effect of the cavity.

The studies show that for most materials, increasing the surface roughness leads to an increase in the number of surface cavities. The result is that cavities have the opposite effect in radiation measurements. Therefore, if the reflected energy decreases, the radiated energy increases. The Rayleigh roughness criterion can be used to characterize the surface roughness. The surface is optically smooth depending on the height of the surface topography (the difference between the deepest valley and the highest peak) and the wavelength of light and the angle of the incident beam.

For the surface roughness to influence the spectral contrast, the surface topography should be greater than the wavelength of incident light rays. Surfaces of the IR range (7–16 microns) are considered to be optically rough when the height of the topography is equal to or exceeds 1–20 microns, depending on the angle of incidence. The optical smooth surface is dominated by surface reflection, while the optical rough surfaces are increasingly affected by diffuse reflection and volume scattering.

Infrared spectroscopy is mainly used for quantitative and qualitative analysis of various substances composition. There are many obstacles to surface infrared analysis, as the properties and conditions of the test specimens must be the same. The main problem that arises when studying the surface of natural stone samples is the heterogeneity of its mineral and chemical composition, which extends to the sample area. As a result, various spectra are obtained that are difficult to identify without a previously prepared control sample. The full infrared spectrum of the surface of Pokostovsky granodiorite (Gray Ukraine) and Bukivsky gabbro (Galant) is shown in Fig. 1

Considering the full range of natural stone, we see that a large number of peaks range from 1400 cm-1 to 300 cm-1. For this reason, it was decided to consider this wavelength range to identify differences between these types of stone and to determine the natural stone processing efficiency. As can be seen from Fig. 1, Pokostivsky granodiorite (Gray Ukraine) and Bukivsky gabbro (Galant) have different infrared spectra, which is explained by the difference in the mineralogical composition of natural stone. In addition, the spectrum of Pokostiv granodiorite (Gray Ukraine) has more peaks than that of Bukivsky gabbro (Galant). This is because there are more minerals in Pokostovsky granodiorite (Gray Ukraine) than in Bukivsky gabbro (Galant). Thus, Bukivsky gabbro (Galant) consists mainly of plagioclase and pyroxene, and Pokostivsky granodiorite (Gray Ukraine) consists mainly of microcline, plagioclase, quartz and biotite. It is also common that these rocks are within the same geological zone. The rock-forming minerals of these rocks have a total wavelength. Since these rocks have one common mineral - plagioclase, analyzing the spectra of two types of stone shows the same wavelengths belonging to plagioclase (Table 1).



The spectrum of natural stone, which corresponds to a common mineral - plagioclase

Type of stone	Wavelength, cm-1 / Absorption, units							
Pokostovsky granodiorite (Gray Ukraine)	1112 / 0,67	1064 / 0,66	1020 / 0,65	771 / 1,13	727 / 1,14	603 / 0,88	540 / 0,92	428 / 0,75
Bukin gabbro (Galant)	1110 / 0,73	1066 / 0,78	1016 / 0,69	769 / 1,12	721 / 1,06	603 / 0,79	540 / 0,7	430 / 0,78