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About application prospectivity of rocks with different geological and morphological features as basic raw component for free-cement binder production

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Abstract. The opportunity of production of effective non-cement binders with using of different morphological and structural types of aluminosilicates and silicates is studied on the basis of data of phase and structural features of natural raw materials – perlite and quartz sand.

Introduction

Contemporary range of mineral hydraulic binders is limited generally by Portland cement and composite binders on its base as well as lime and lime-silica autoclave binders. That leads to development of such negative effects in high-basic materials as destruction at high temperature and aggressive environment.

Therefore, the development of production technology of free-cement binders based on raw of different genesis is an actual nowadays. One of these types of the binders is a nanostructured binder (NB), that can be produced with using of wide range of silica-bearing and alumosilicate materials including quartz sands, quartzitic sandstones, sandstones, perlite. These raw materials can be used in binder production, depending on geological peculiarities of certain regions of Russia. Application of the binders like NB allows partially replacing cement when production of differently purposed construction materials. Especially, it is actual because of continuous growth of cement cost that depends on geographical location of cement plants as well as negative effect of cement production on ecosphere. [1].

In this work the reviewed analysis of natural and industrial raw materials for free-cement binder production is given. The classification of genesis, chemical composition and state of aggregation (Fig. 1), as well as the prospective estimation of this raw are offered.

Perlite is a very valuable material in construction industry. Global perlite production is always in the process of growth. The main manufactures of perlite material can be considered USA (more than 1 million tons per year) and Greece (800–900 thousand tons per year). Traditionally, in large quantities, perlite is produced in the other countries like Turkey, Hungary and Japan. For last years, the one of the leaders in perlite production became China. [4].

A widespread distribution of this type of material makes it applying very prospective for free-cement binder production.

Quartz sand is a product of weathering of acidic magmatogene-intrusive rocks (for example, granites) and presented by crystal silica-bearing material quite constant phase and chemical composition. Unlike quartz sand, perlite is an alumosilicate form of volcanic glass, predominantly with acidic composition. The peculiarities of its structure, justified with magmatogene-effusive genesis, consists of amorphous or nanocrystal condition.

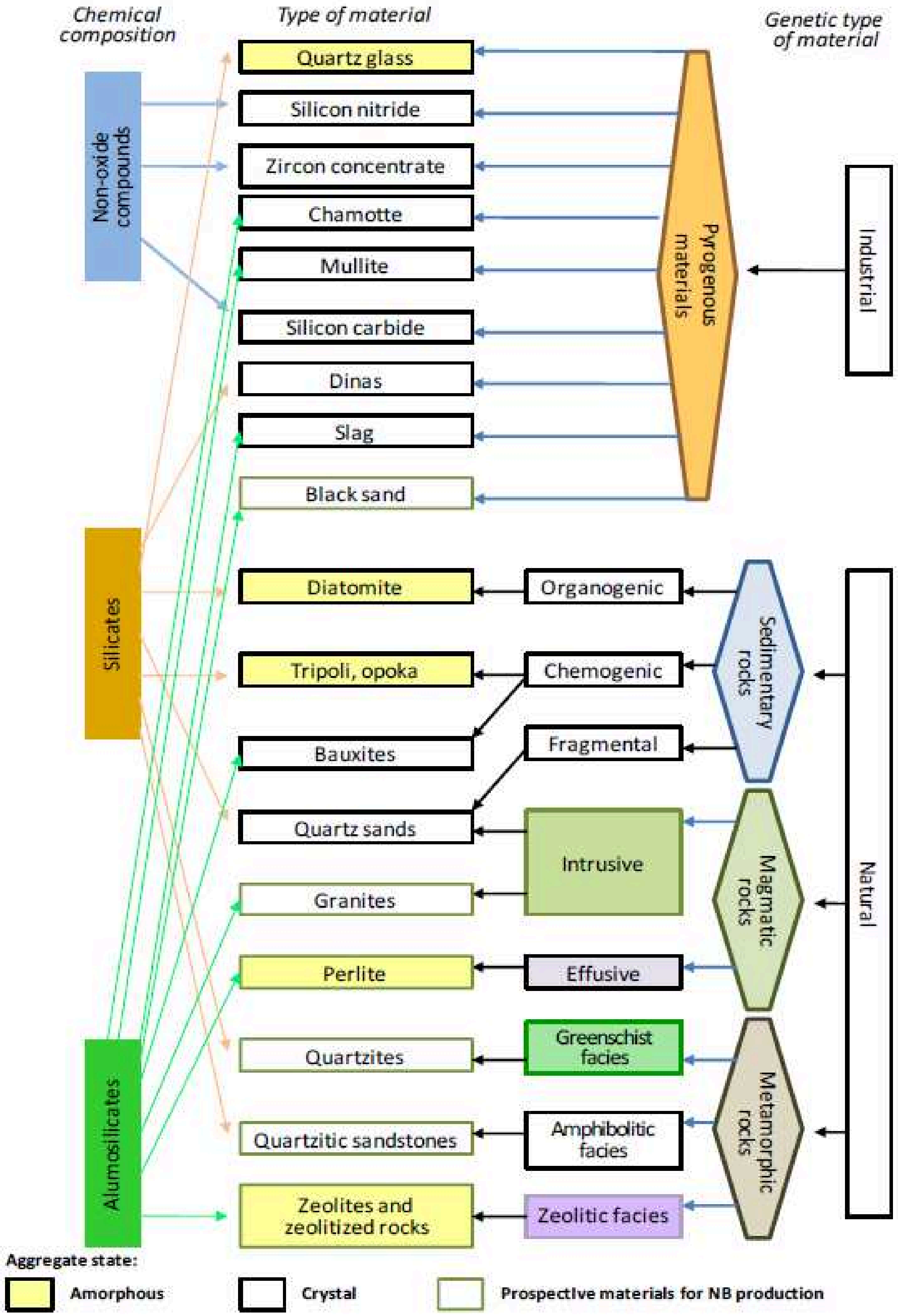


Fig. 1. Classification of natural and industrial materials used for cement-free binder production

Perlites, presented as a species of volcanic glass are the products of volcanic activity. They were formed in the result of rise a natural acidic silicate magmatic melted mass from beneath of underground, that is due to lose of significant quantity of votalities came on the surface in the form of lava. It is necessary to note, that such factors as speed of cooling of lava and its chemical composition affect the process of a volcanic glass formation.

At slow cooling, has a tendency to be crystallized, turning to the rocks like granite. At the same time, at quick cooling of lava, volcanic glassy rocks are usually formed. [5].

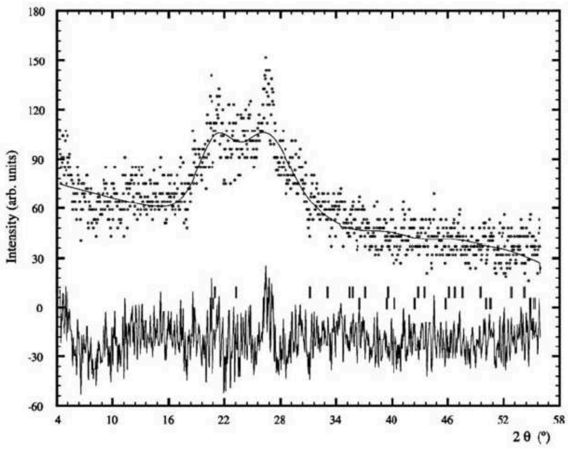
Describing of phase and structural condition of X-ray amorphous (nanostructured) materials can be contradictorily done on the base of crystal "structures-approximants". Here the curve of X-ray scattering for amorphous material can be modeled as a result of scattering based on summation of nanosized crystallites. Size effects like nanoscale of crystallites will be occurred in significant spread of the X-ray reflections. Applying this method, its possible to obtain not only concentration parameters of nanosized phases, but to determine dimensions of their crystallites in isotropic approach, that is, to run an X-ray microstructural analysis.

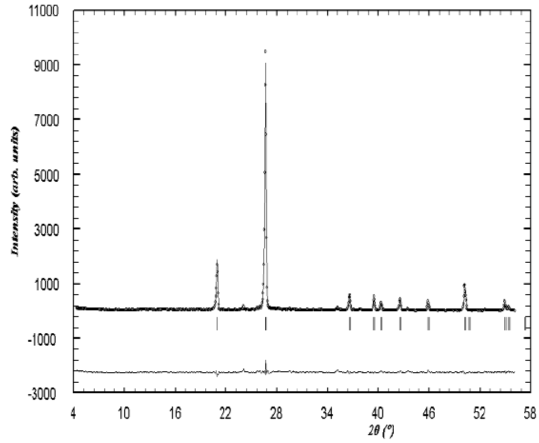
Materials and methods

As reference compositions were took crystobalite, tridymite and α-quartz. Full profile calculations with using FullProf software were made via use of method of refining of the scale (concentration) and microstructural parameters (dimensions of crystallites in isotropic approach).

Results

The calculations made with this method showed the absence of tridymite phase in the studied perlite. X-ray diagrams with Rietveld calculation presented on Figure 2.





a *b*

Fig. 2. X-ray diagrams with Rietveld calculation for perlite (a)and quartz sand (b)

Quantitative values of the parameters for phase-nanosized heterogeneity of the studied materials listed in table 1.

Table 1

Quantitative concentration and dimension parameters of nanostructured SiO_2-materials

Mineral components	Weight, %	CSR (coherent scattering region), nm
Perlite		
Crystobalite	23	2
α-quartz	77	1,2
Quartz sand		
α-quartz	90	450
β-quartz	10	24

Structural characteristics fully correspond to volcanic-sedimentary origin of perlite in the form of X-ray amorphous mineral formations that is responsible for high-energy state of a material and allows intensifying the process of nanostructured binder production.

Conclusion

For free-cement binder's production, crystal and amorphous silica-bearing and alumosilicate rocks may be applied. In this respect in can be concluded, that the prospective raw materials for free-cement binders production are granites and opoka.

The choice of the one or another material is made taking into account a volume of the deposits of silica-bearing materials in a certain region, where production of free-cement binders is planned.

A majority of cement binders on the domain and global markets formed an issue of adaptation of cement-based materials for applying them to severe service conditions affected the durability and entirety of materials [6]. Functional modification of cement binders with different additives, reducing at some extent the consequences of severe service conditions such as high temperatures, acid corrosion, temperature gradients etc. provokes increasing in the cost of binders and significant sophistication of production technology. The data given in this article allow concluding of a wide range of materials for production of new types of free-cement binders, applying of which will provide a production of high-performance construction composites.

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