COAL-FIRING WASTE TO NANOCOMPOSITES FOR 3D PRINTING

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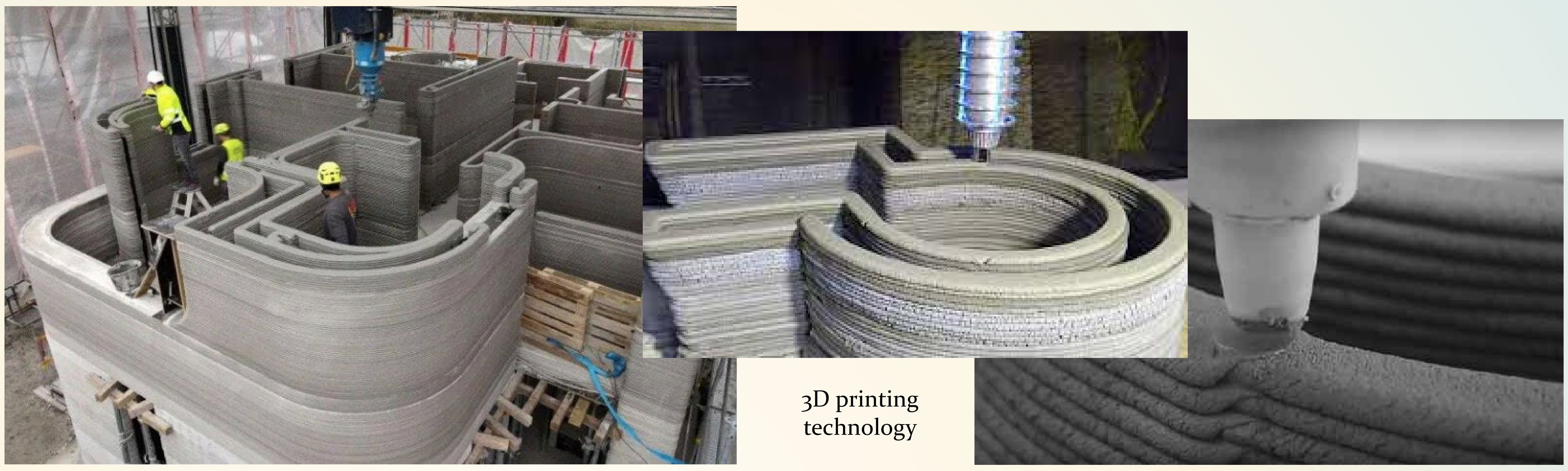
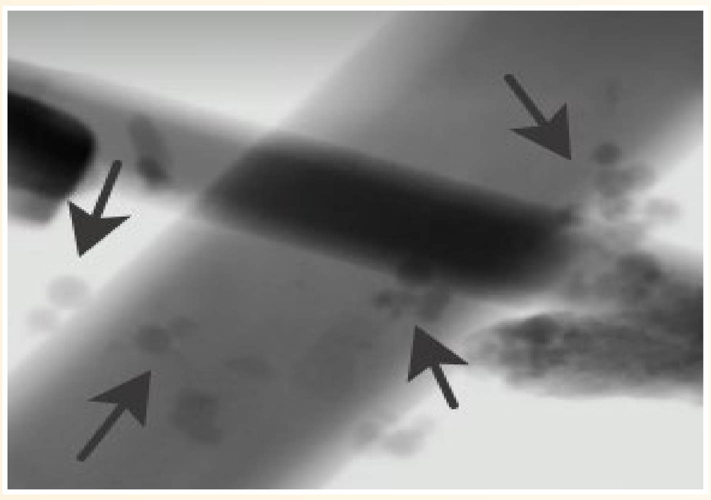
3D printing technologies are developing extremely rapidly and have recently been actively used in various areas of production [1]. One of the most used methods is printing by layer-by-layer extrusion using organo-mineral raw material mixtures. The essence of this method is to extrude a quick-hardening mixture. An important role is given to the composition of the ink - the raw mixture. The introduction of organomineral complexes into the compositions of gypsum compositions makes it possible to regulate not only their structural-mechanical, but also technological properties [2, 3].



3D printing technology

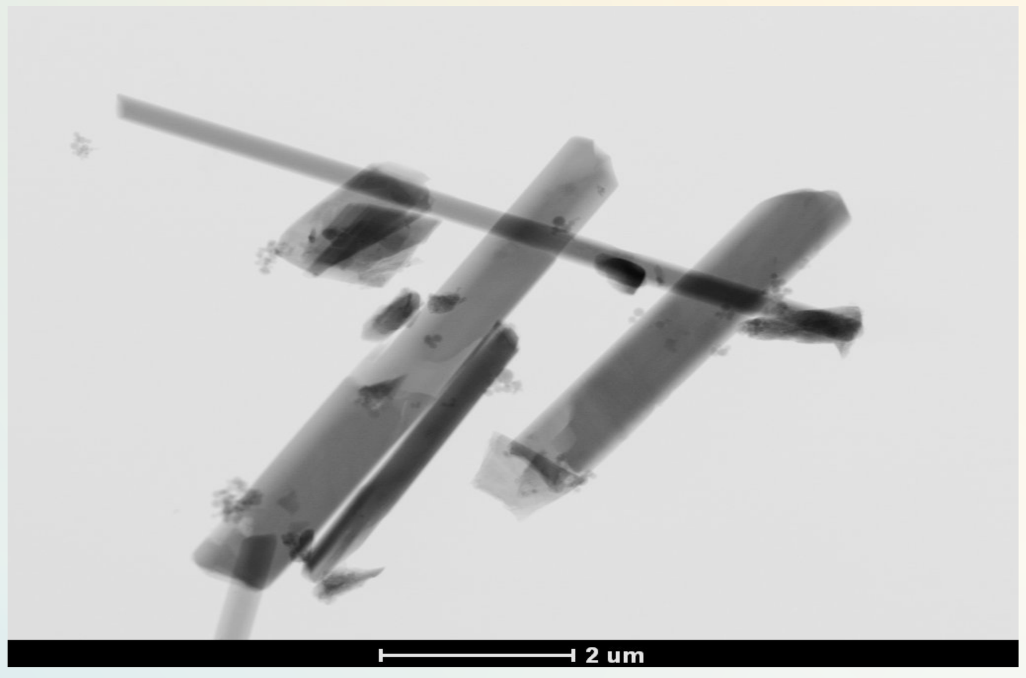
To substantiate the possibility of using a nanocomposite based on a gypsum mixture, the authors conducted experiments using mixtures of various compositions. The dispersity of the applied nanofillers, as well as the type of viscosity modifiers, differed significantly in the experiments.

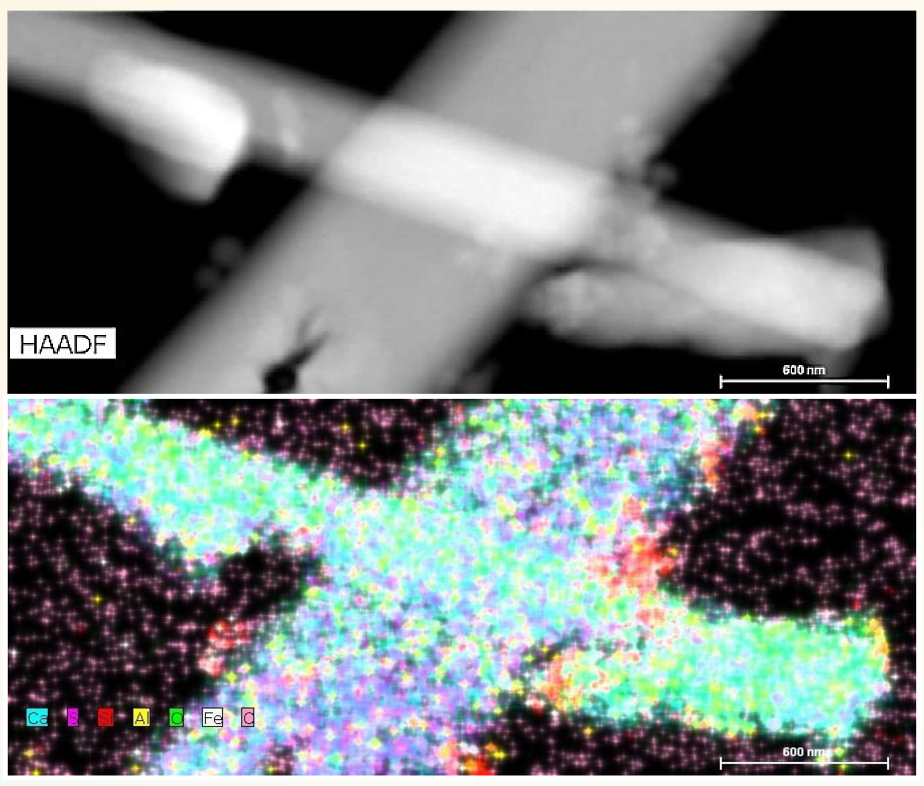


The particle size of the aluminosilicate filler is from 5 to 50 nm, which contributes to the reinforcement of gypsum stone from nano- to micro-level.

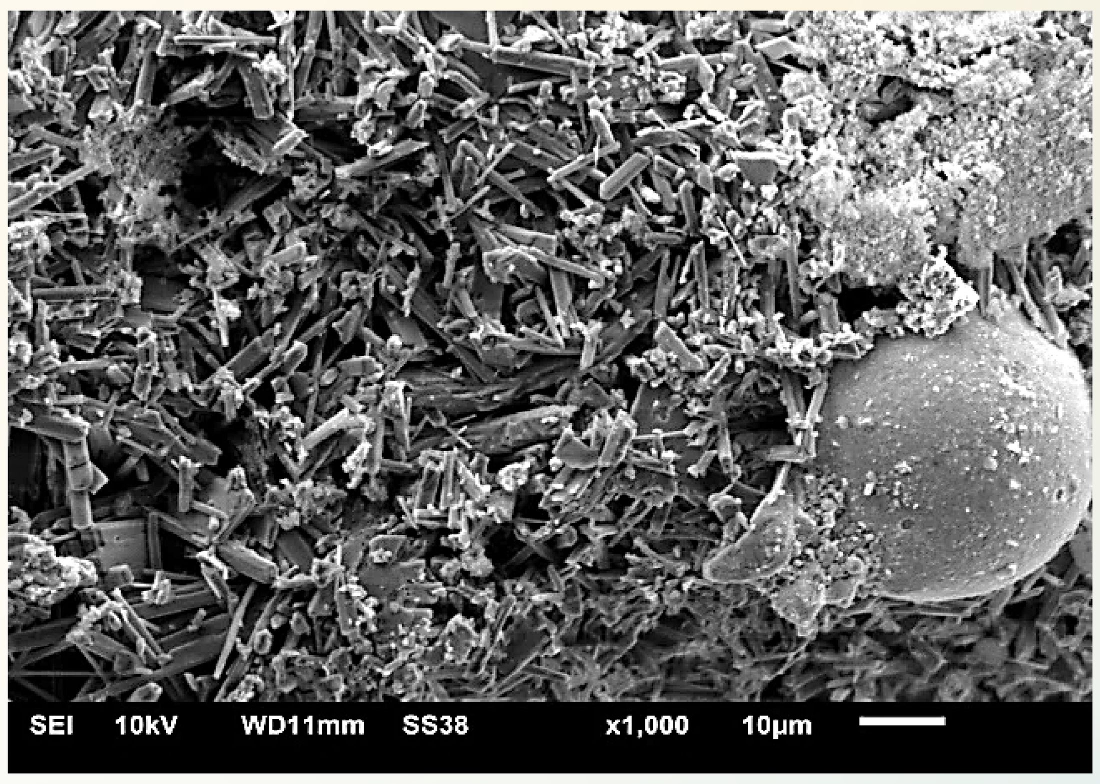
Based on the results of the studies, the effectiveness of the use of a nanomodifier based on an aluminum-containing filler of nanosized dispersion, metakaolin and a polycarboxylate plasticizer was established. The introduction of a nanomodifier into the composition made it possible to increase not only the structural and mechanical properties of the gypsum nanocomposite, but also the manufacturability of the raw mixture. Amorphous aluminosilicate was a man-made filler. The intergranular voids of gypsum stone were filled with particles of an active mineral additive - metakaolin. The active additive entered into chemical interaction with calcium hydroxide, as well as other impurity alkaline oxides. As a result, a dense structure of the gypsum composite was formed.

Based on the results of the microstructural and spectral analysis, a comparative analysis was carried out. Gypsum crystallization is noted on the surface of the introduced aluminosilicate filler with the formation of a high-strength fine-crystalline stone structure in the future. The spectrogram shows the superposition of reflections of the crystallizing substance - gypsum submicroparticles and the "substrate".



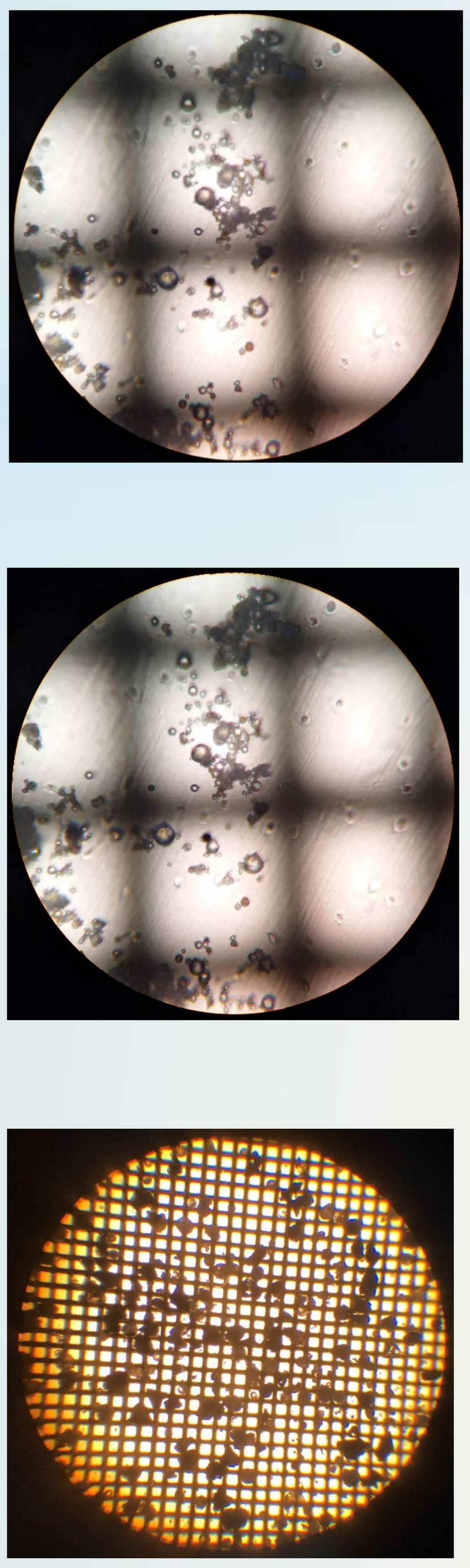


TEM image of a sample of gypsum dispersion-reinforced stone

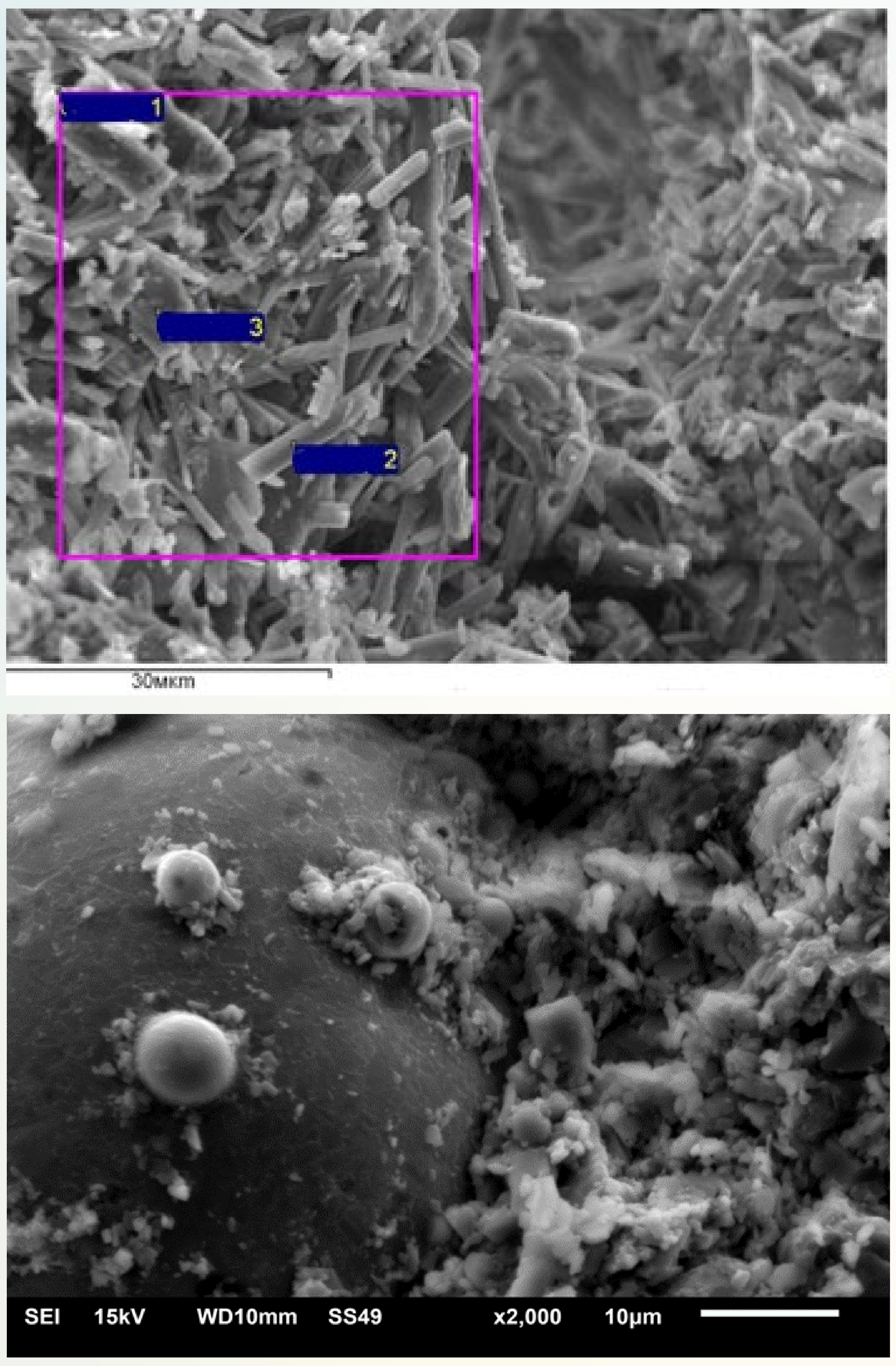


Microstructure of gypsum modified stone

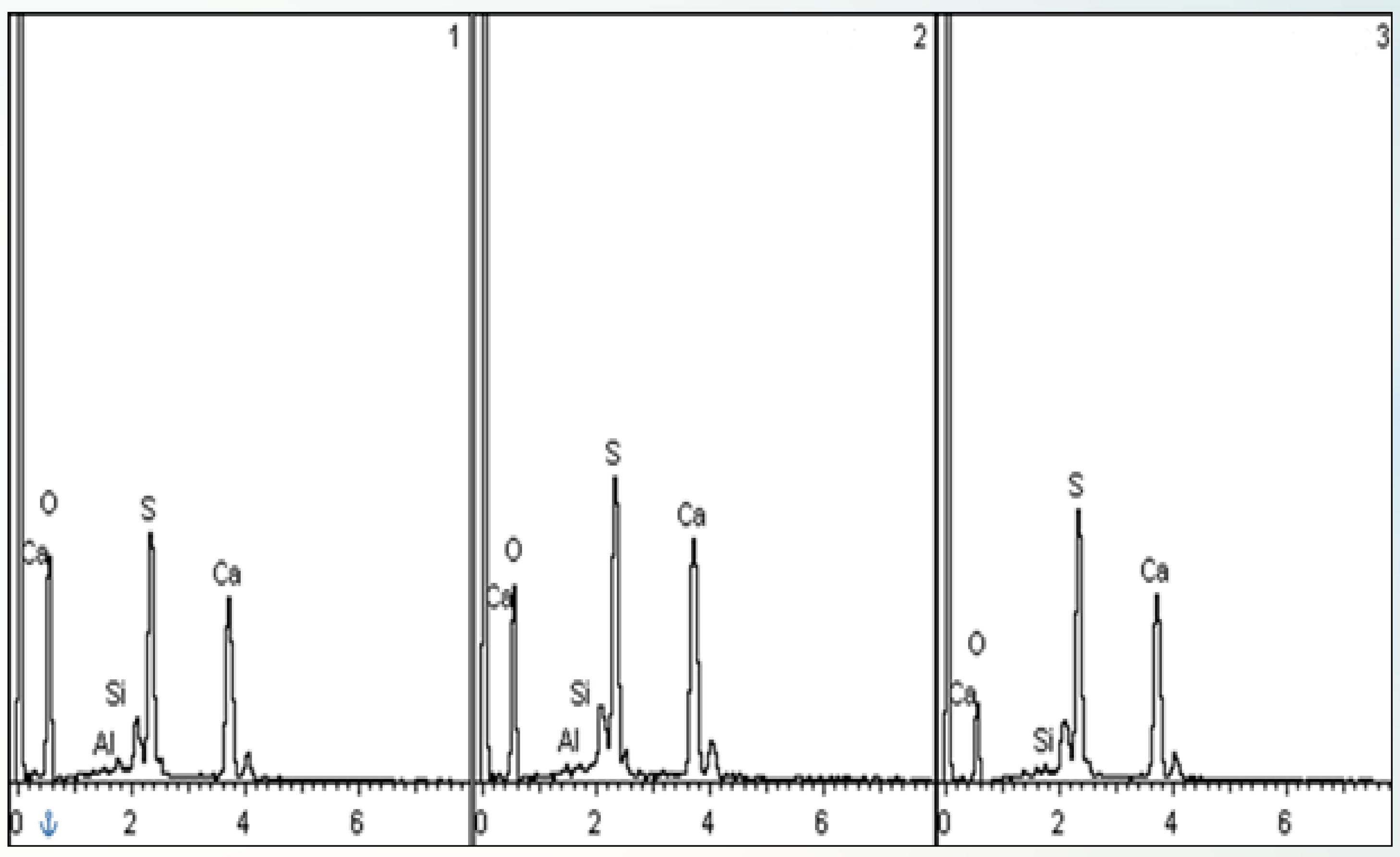
The introduction of a nanomodifier into the composition made it possible to increase not only the structural and mechanical properties of the gypsum nanocomposite, but also the manufacturability of the raw mixture. Amorphous aluminosilicate was a technogenic filler. The intergranular voids of gypsum stone were filled with particles of an active mineral additive - metakaolin. The active additive entered into chemical interaction with calcium hydroxide, as well as other impurity alkaline oxides. As a result, a dense structure of the gypsum composite was formed. The synthesized structure is represented by calcium sulfate dihydrate crystals and an amorphous phase of aluminosilicate filler.



Micrograph of an aluminosilicate component



Microstructure of gypsum modified stone



Registered spectra of a gypsum stone sample

Quantitative indicators of the chemical composition of the gypsum composition at the age of 28 days of hardening in air-dry conditions, in atomic %

Range	O	Mg	Al	Si	S	K	Ca	Fe
Range 1	73.05	2.16	6.13	13.89	0.99	0.95	1.97	0.85
Range 2	79.02	0	0.15	0.47	10.00	0	10.36	0
Range 3	75.43	0.28	0.20	0.76	10.95	0	12.38	0
Maximum	79.02	2.16	6.13	13.89	10.95	0.95	12.38	0.85
Minimum	73.05	0.28	0.15	0.47	0.99	0.95	1.97	0.85

Conclusions

The conducted studies confirm the possibility of using ash and slag waste from thermal power plants in the production of effective modified gypsum compositions. It has been established that the aluminosilicate component makes it possible to more than double the strength of the modified stone. Thus, the studies have confirmed the effectiveness of using an aluminosilicate product as a component of compositions based on low-grade gypsum binder.

Obtaining aluminosilicate microspheres by enrichment of ash and slag waste

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References:

[1] R.H. Mukhametrakhimov, I.M. Vakhitov, Izvestiya KGASU 4(42) (2017) 350–359.
[2] N.I. Alfimova, E.E. Shadsky, N.A. Nikiforova, Izvestiya vuzov. Investments. Construction. Real estate. 2(17) (2016) 120–128.
[3] Y. Chen, S. Chaves Figueiredo, Z. Li, Z. Chang, K. Jansen, O. Çopuroğlu, E. Schlangen, Cem. Concr. Res. Elsevier Ltd. 132 (2020) 106040.