



To Whom It May Concern

Ref. 471/2021

Košice, October 6th, 2021

Re: Review of the foreign scientific supervisor

**REVIEW
of the foreign scientific supervisor
RNDr. Matej Baláž, PhD. (Institute of Geotechnics, Slovak Academy of Sciences)**

for the dissertation thesis of MSc. Lyazzat A. Mussapyrova

**„Technology of hydrometallurgical processing of copper smelter slag “
submitted for the degree of Doctor of Philosophy (PhD.) in the speciality
6D072000 - Chemical Technology of Inorganic Substances**

Copper smelter slag is an industrial by-product and a potential source of valuable metals. Its treatment is especially relevant in countries like Kazakhstan, where a large amount of this material is produced at processing plants.

The thesis under consideration proposes an efficient approach for the recovery of valuable metals from the copper smelter slag. In its theoretical part, the waste material is described in detail, together with the possibilities of metals leaching, including different potential leaching agents. The leaching models used to explain the possible mechanism are also mentioned. Subsequently, the field of mechanical activation (achieved by performing high-energy ball milling process) is described and in the last part, the possibility to use this method for the improvement of leaching of metals from various minerals is provided.

The experimental work focused the selective leaching of copper and zinc from the slag by using a combination of sulphuric acid and potassium dichromate. Acceptable results were achieved already without the use of milling, however, upon introducing the mechanical activation, the performance could be significantly improved. At the end, the feasibility of the process in terms of recommendations and a processing scheme is provided.

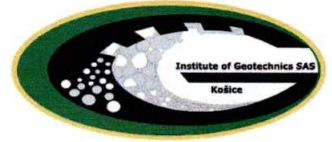
The results and discussion in the thesis are written in a comprehensive and detailed manner, in a way how MSc. Mussapyrova worked during her whole PhD. study. I had the pleasure to work with her closely in person at two occasions. Firstly, she absolved a scientific internship at the Department of Mechanochemistry at the Institute of Geotechnics, Slovak Academy of Sciences in Košice, Slovakia under my guidance. Her stay (June 4 – July 15, 2019) was focused on the mechanical activation of copper smelter slag in both planetary and attrition mills in both dry and wet mode. The conditions of mechanical activation in terms of sample mass, milling time and rotation speed were systematically optimized using a Design of Experiments (DoE), namely Taguchi orthogonal array. MSc. Mussapyrova learned how to use the attrition ball mill in about two weeks, after which she could work alone. Moreover, she was very quick in collecting and evaluating the research results.





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She was keeping the time plan we made without problems and also her attitude towards additional work which often occurred was positive. The second time we have met for a longer time was during my stay during a research visit at Al-Farabi University in December 2019. At that time, we have discussed the possibility to optimize leaching conditions and prepared a clear and ambitious experimental plan. During the year 2020, MSc. Mussapyrova strongly adhered to this plan and performed the agreed leaching experiments and subjected the obtained solutions to the determination of the content of dissolved metals. The obtained results were then used as an input into the statistical calculations using a Minitab software, with which the applicant learned to work.

The results received during our collaboration were planned to be presented at the international conference 10th International Conference on Mechanochemistry and Mechanical Alloying (INCOME2020) that should have taken place in Cagliari, Italy in June 2020, however, it was postponed to 2022 due to COVID-19 pandemic. The obtained results formed the basis of recently published article published in CC/IF Q1 journal Journal of Materials Research & Technology with IF above 5. MSc. Mussapyrova is a first author in this publication. However, the review process was quite difficult, as one of the reviewers has requested a significant amount of additional work done in a very timely manner. However, MSc. Mussapyrova, due to a great support of Dr. Nadirov, was able to perform the requested tasks in time and delivered the results to me in advance before the submission deadline.

As a foreign scientific supervisor of MSc. Lyazzat A. Mussapyrova, taking into account the results obtained in the thesis and the personal qualities of the applicant, I am of the opinion that his dissertation thesis meets the qualification requirements of an international standard for a Ph.D. and I strongly endorse it for the presentation to the Dissertation Council of your University and I am sure that the Ph.D. student deserves awarding the Ph.D. degree in the specialty 6D072000 - Chemical Technology of Inorganic Substances. I also strongly endorse her further engagement in the academic / research field.

Sincerely yours,

A foreign scientific supervisor

RNDr. Matej Baláž, PhD.