E R A•M I N 2

RESEARCH & INNOVATION PROGRAMME ON RAW MATERIALS
TO FOSTER CIRCULAR ECONOMY

ERA-MIN Joint Call 2013 Results:

Summary Reports

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Joint Call 2013 results: Summary Reports

Five ERA-MIN funding agencies, **FCT (Portugal), NCBR (Poland), TEKES (Finland), UEFISCDI (Romania) and VINNOVA (Sweden)**, committed together a total of €3.9 million of national public funds to support their national participants in the selected transnational R&D proposals submitted to the **first ERA-MIN Joint Call 2013.**

18 full proposals were submitted in total from 67 participants. Out of the 18 proposals, 14 passed the eligibility check. After evaluation and ranking, 4 transnational projects, involving 19 organisations, were finally selected for funding: project acronyms **CELMIN, GEOSULF, MAXI and SUSMIN**. The total project funding was €2.9 million and the total costs were €3.9 million. The total success rate of the Joint Call 2013 was 22.2% (4 funded/18 submitted proposals). When considering the 14 eligible proposals the success rate increases to 28.6 %.

The **scope** of this first Joint Call 2013 was needs driven research on **"Sustainable and responsible supply of (non-energy) primary resources"** with the following sub-topic areas:

1. Exploration,
2. Extraction,
3. Mine closure and rehabilitation,
4. Minerals processing,
5. Metallurgy.

Nine proposals targeted more than one topic sub-area and three proposals addressed metallurgy as a second/third topic sub-area (Figure 1).

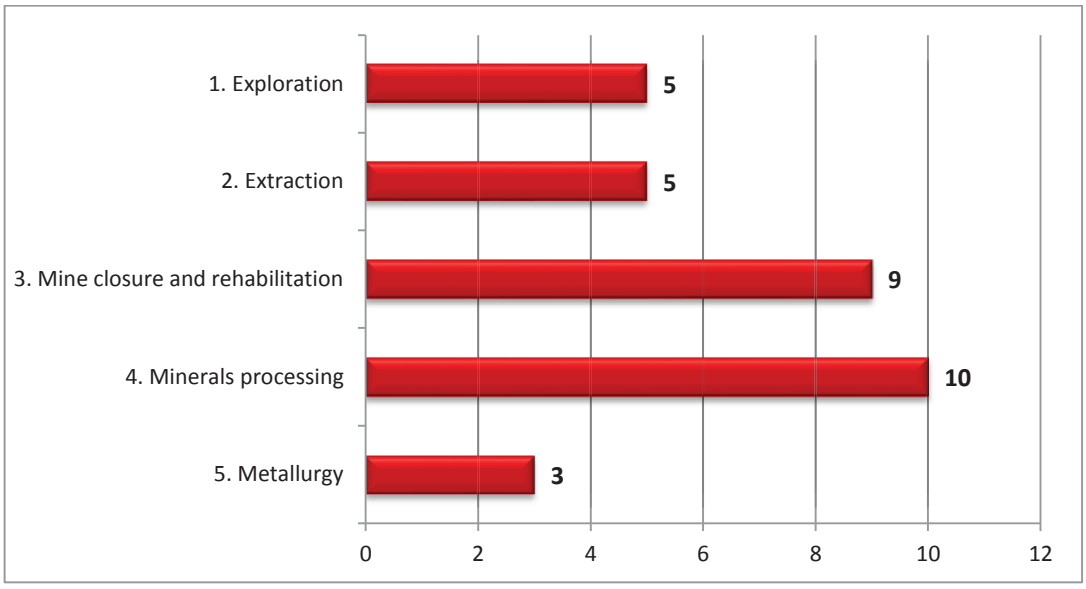


Figure 1- Distribution of the 18 submitted proposals by sub-topic areas.

In terms of country participation, there was an oversubscription rate for all countries when comparing the requested funding with the indicative committed budget, which shows a high interest in research to address material scarcity.

In terms of industrial participation, SMEs accounted for 26% of the participants in submitted projects.

The type of organization with highest participation in the 4 funded projects was higher education institutions, representing 47% (Figure 2).

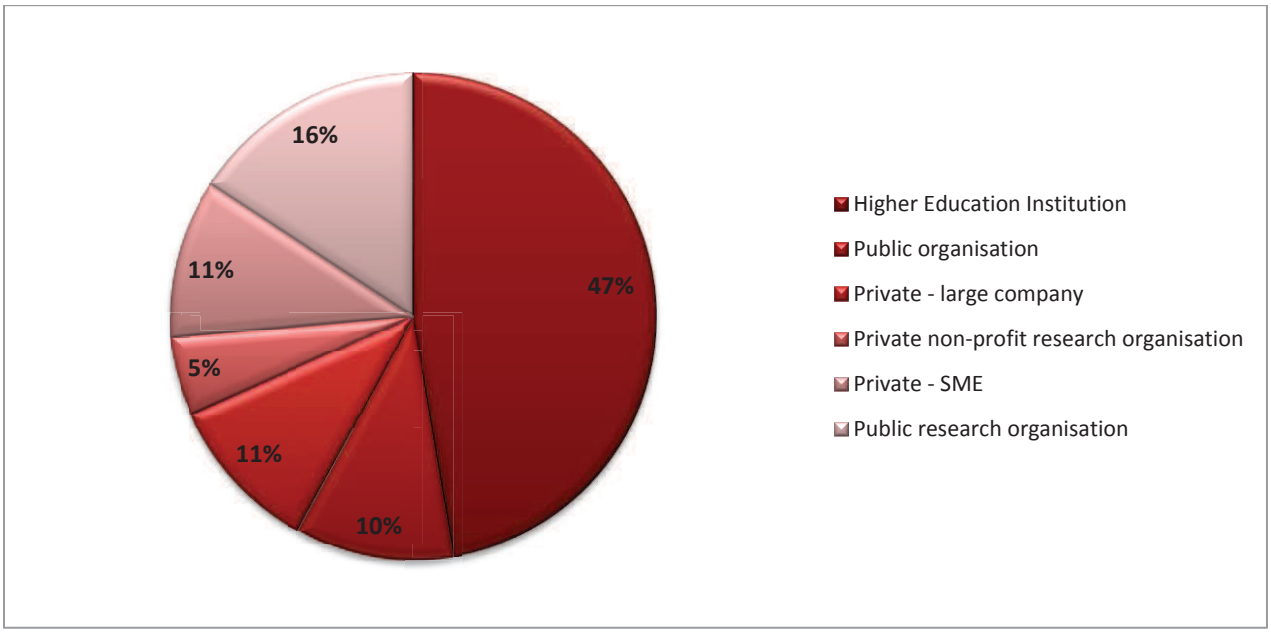


Figure 2- Distribution of types of organisations in the 4 funded projects.

In terms of country participation, all countries participating in the Joint Call funded at least two national research organisations of the funded projects (Figure 3).

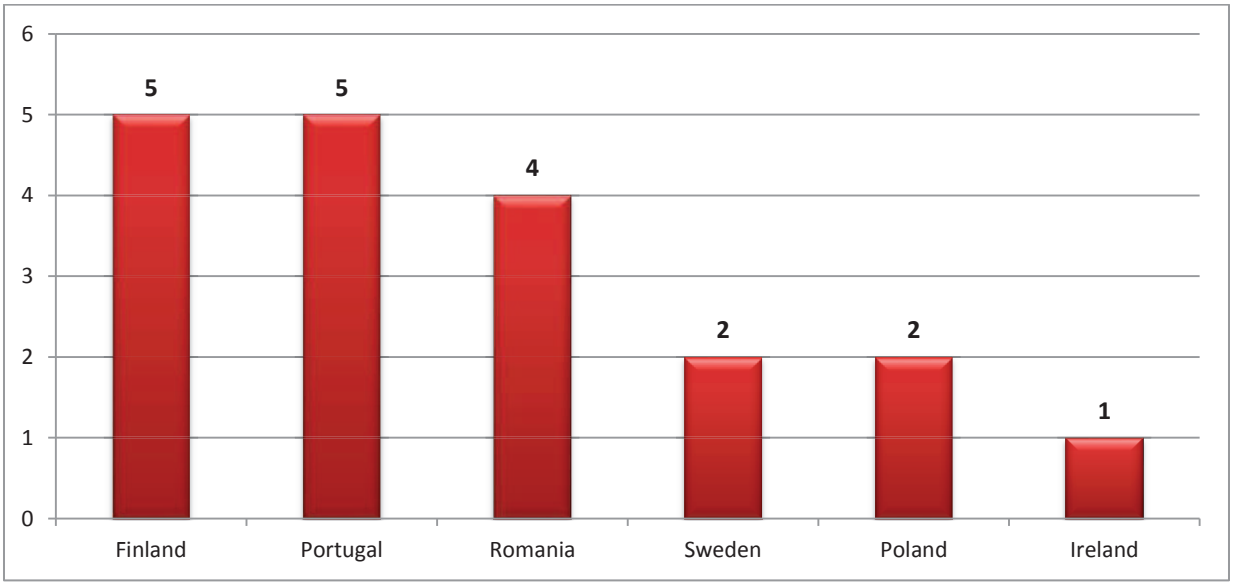


Figure 3- Geographical participation in the 4 funded projects

The 3 out of 4 funded projects involved 38 young researchers which represents the 40% of researchers participating in these projects (Figure 4).

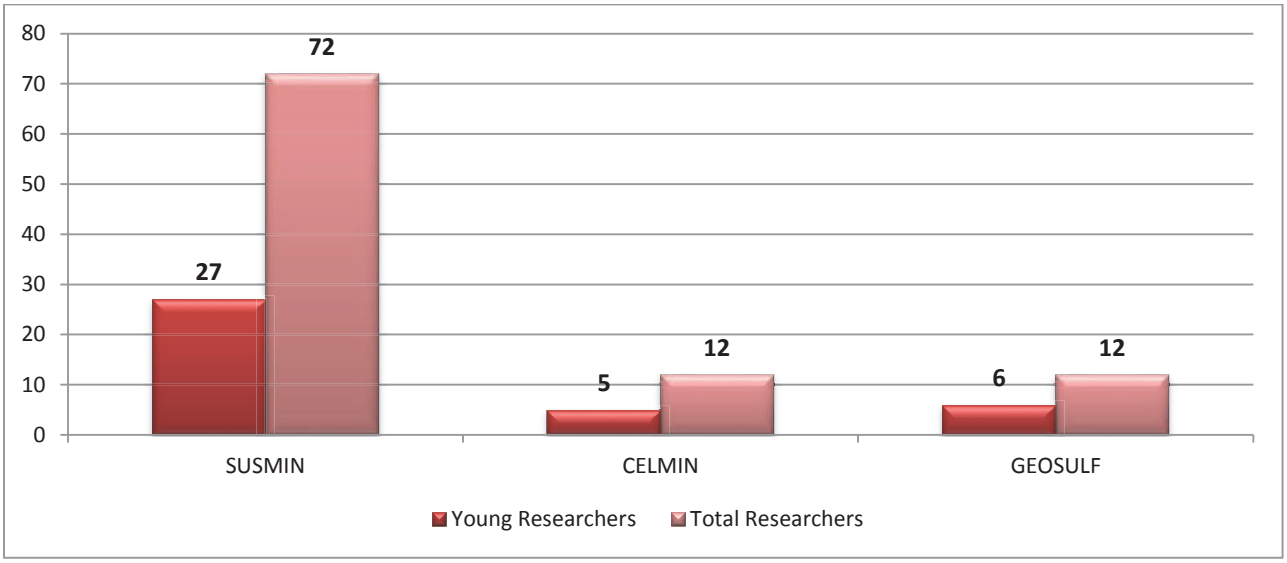


Figure 4 – Young and total researchers participating in the 4 funded projects

It is highlighted mentioned that 49% of the researchers involved in these funded projects are female which represents a good indicative of gender balance (Figure 2).

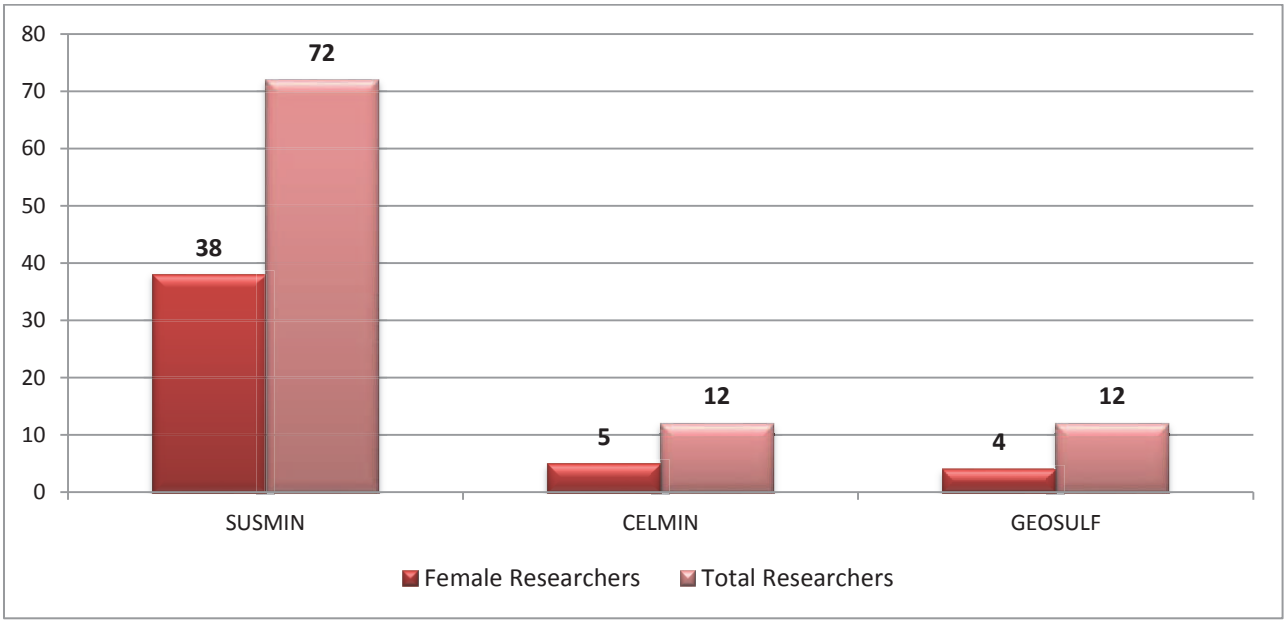


Figure 5 - Female and total researchers participating in the 4 funded projects

These projects have produced 49 publications (Annex) and 37 temporary jobs.

Through this ERA-MIN Joint Call, the funded projects will continue the collaboration with industrial partners and new industrial collaborations will be created.

Project CELMIN

Utilisation of green chemicals in non/energy extractive industries: Preparation of modified nanofibrillar celluloses (NFC) for flotation, flocculation and dewatering, and water purification in mining industry

Sub-topic: Extraction, Mine closure and rehabilitation, Minerals processing
Project Coordinator: University of Oulu (Finland)
Consortium partners:
IST Lisbon (Portugal); NUCBM (Romania); Sibelco Lda (Portugal); Sojitz Beralt Tin & Wolfram S.A. (Portugal)

Project total funding: 329.911€
Total costs: 449.911 €
Duration: 30 months (2014-2016)
Webpage

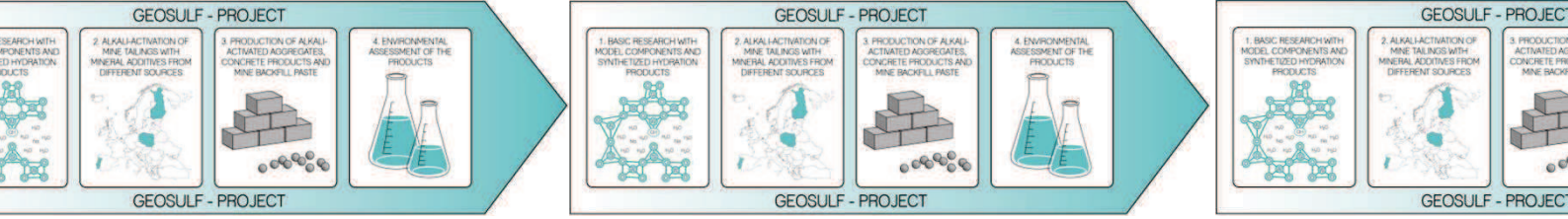
SUMMARY and RESULTS:

The progressive industrialization of almost any country worldwide increases the demand of mineral and metal resources. The high demand leads to the processing of ores possessing a high complexity of its components. Annually around 400 million metric tons of ores are crushed and ground to particles to liberate the individual minerals. Froth flotation is the main beneficiation method for the efficient separation of desired minerals from gangue materials. Oil-derived flotation reagents used, however, are potentially harmful for human beings, animals and the environment, and therefore biocompatible candidates would be needed. Nanocellulose or cellulose nanocrystals are potential agents to replace commercial flotation reagents or flocculation agents in dewatering of finely ground particles to achieve a sustainable and efficient processing of ores.

The aim of the project was to design various chemical modifications affecting the functional properties of nanocelluloses and study those nanocelluloses with respect to their function in selective flotation (collector/depressant) and flocculation of finely dispersed mineral particles. Additionally, the role of adsorption interaction of cellulose chemicals on given minerals in the performance of froth flotation was aimed to study in order to get fundamental understanding for the basis of the development of tailored nanocellulose chemicals.

Project showed that cellulose can be chemically modified and properties adjusted such a way they can be used as green chemicals in froth flotation and dewatering/flocculation of mining industry. During the project it was showed that functionalized nanocellulose collectors, depressants or flocculants have a performance similar than oil-based chemicals with lower environmental impact. Functionalization based on increased hydrophilicity with increasing anionic charge and increased amphiphilicity by attaching the amino groups with extending alkyl chain lengths were designed. The importance of the free surface charges of the nanocellulose on the adsorption behavior on minerals, as well as on the particle- bubble attachments during flotation experiments was recorded. The investigations with binary quartz-hematite and quartz-alumina systems showed that nanocelluloses can selectively interact with one mineral rendering its wetting properties to more hydrophobic and thus separate the mineral efficiently from the gangue mineral. The results also suggest that nanocellulose carboxylation and sulfonation may be a route for selective flocculation e.g. in quartz/hematite separation.

Cellulose based chemicals to have a great potential in mineral processing. The periodate oxidation of cellulose to dialdehyde cellulose and the subsequent functionalization of it were proved to be technically feasible. For commercialization, the optimization of each process step would be needed in order to clarify full economical potential. Also a novel route to produce nanocellulose chemicals by using deep eutectic solvents could be an economical and environmental sound alternative and would be a worth of research.



Project GEOSULF

Utilization of sulphide mine tailings in geopolymer materials

Sub-topic: Mine closure and rehabilitation, Minerals processing
Project Coordinator: University of Oulu (Finland)
Consortium partners:
AGH University of Science and Technology (Poland);
University of Aveiro (Portugal)

Project total funding: 601.025 €
Total costs: 781.052 €
Duration: 40 months (2014-2017)
Webpage: GEOSULF

SUMMARY and RESULTS:

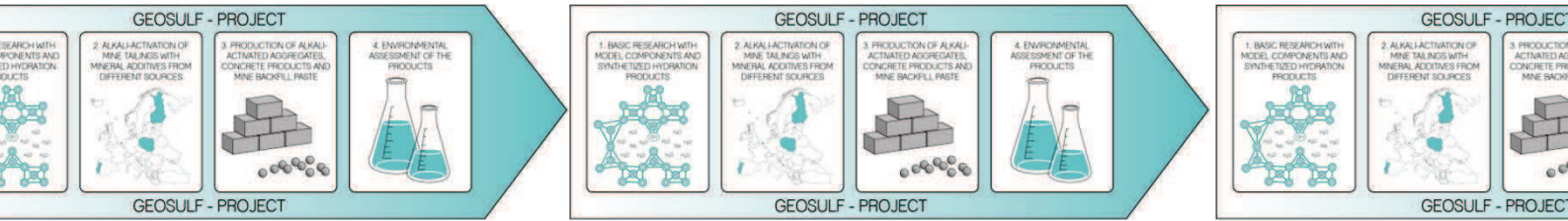
Disposal of mine tailings is one of the most important environmental issues during mine lifetime. In the EU, mining and quarrying are contributing 727 million tons waste, which is 28.3 % of the total waste amount. Some of these wastes such as sulphidic mine tailings consist of many harmful components which can cause several environmental and ecological risks because of their tendency to oxidize in the presence of water or air.

Alkali activation or geopolymerization is known to be an effective method to stabilize hazardous waste materials including the mine tailings. This aim of this project was to understand more deeply the methods how different elements can be stabilized and what are the possibilities to stabilize mine tailings with high amount of sulphates. The project involves the contribution of three different universities from Finland, Poland and Portugal in order to provide knowledge for more sustainable disposing methods for mine tailings all over the Europe.

The Finnish mine tailings studied in this work had chemical composition promising for alkali-activation. However, the reactivity of the material was low, which means that there is need for co-binder to utilize these tailings in geopolymer materials. With a proper co-binder material such as blast furnace slag or metakaolin, it was possible to achieve strength required in construction materials. The Portuguese mine tailings had low aluminosilicate content, so it was proposed to use as an aggregate rather than a reactive component.
Even though there was a possibility to achieve good mechanical properties of geopolymer based on tailings and slag, the environmental analysis shows that there was increased leaching of oxyanions such as As and V after geopolymerization. Although the stabilization of anionic species was poor, it was possible to stabilize a large amount of different cationic species into the geopolymer structure. Longer curing period improved also the immobilization of oxyanion species. The immobilization mechanism should be further examined in order to understand the role of different parameters from stabilization point of view.

It is possible to use mine tailings as geopolymer aggregates or fillers in concrete. The mine tailings were incorporated into mortar and concrete bricks either as partial aggregate replacement (sand) or in the form of lightweight aggregates previously prepared by geopolymerization of Finnish mine tailings. This introduction of mine tailings promoted obvious benefits in the fresh and hardened state of mortars and concretes. The introduction of mine tailing into a ceramic brick tile paste was also evaluated and it is a viable solution with improved final properties for this type of products. Nevertheless, the viability of this solution still requires further studies.

The project shows promising results to use of sulphidic tailings as geopolymer aggregates in mortar or concrete. The project improved significantly the current understanding on geopolymerization of mine tailings. In future, tailings with different mineralogy (e.g. silicate tailings) might be further studied since the research related to geopolymerization of mine tailings is still at very initial stage.



Project SUSMIN

Tools for sustainable gold mining in EU

Sub-topic: Minerals processing
Project Coordinator: Geological Survey of Finland (Finland)
Consortium partners:
Luleå University of Technology (Sweden);
Geological Institute of Romania (Romania); Wroclaw University of Technology (Poland); Babes-Bolyai University (Romania); University of Porto (Portugal); Trinity College Dublin (Ireland)

Project total funding: 1.227.205 €
Total costs: 1.562.454 €
Duration: 36 months (2014-2016)
Webpage: SUSMIN

SUMMARY and RESULTS:

Although the gold demand has been constantly increasing in past years, the commodity findings have been decreasing and the extraction of gold has complicated due to increasing complexity and decreasing grade of the ores. Additionally, even gold mining could increase economical development, it has also challenges in eco-efficiency and extraction methods (e.g. cyanide). Thus, the novel energy and resource-effici ent methods and technologies for mineral processing should be developed to concentrate selectively different gold bearing minerals. Furthermore, technologies for efficient treatment of mine waters, sustainable management of wastes, and methods to diminish environmental and social impacts of mining are needed. These problems were addressed by the three year long project SUSMIN.

The SUSMIN consortium led by Geological Survey of Finland (GTK) included seven research partners from six EU member states Finland, Sweden, Portugal, Romania, Poland and Ireland. Additionally nine globally on mining industry working industry partners were contributing in the SUSMIN consortium, so implementation of results from the project can be translated into direct and significant economic benefits.

The SUSMIN-project identified and evaluated environmental impacts and economical challenges of gold mining within EU. The objective of the project was to increase the transnational cooperation and to support environmentally, socially and economically sustainable viable gold production

SUSMIN project provided novel information on potential and reliable geophysical methods combination to enhance the gold exploration. Beneficiation studies provided optimized leaching parameters for gold recovery from both cyanide and alternative leaching methods (e.g. thiosulphate) as well as utility of processing aids for selective gold recovery. In addition, water treatment studies verified the effectiveness of different adsorbent materials to treat arsenic containing process effluent, dewatering and seepage waters to meet the environmental standards for mine water quality. Also factors controlling arsenic leaching from gold mine wastes in dynamic conditions were determined. The research verified applicability of environmental monitoring tools and isotopic tracers to assess contaminant migration to mine environment.

Additionally, the study provided new approach for using ecological risk assessment to improve environmental management strategies at mines. Moreover, key issues affecting social license to operate (SLO) at gold mines in EU were canvassed. This knowledge can be utilized to enhance the corporate social responsibility as well as community engagement and management of the relations with the stakeholders in gold mining areas to improve sustainability and long term development of the mining areas.

ANNEX:

- Project CELMIN:

Title	Link (doi or similar)
Flocculation of fine hematite and quartz suspensions with anionic cellulose nanofibers	10.1016/j.ces.2016.04.014
Alkyl aminated nanocelluloses in selective flotation of aluminium oxide and quartz	10.1016/j.ces.2016.01.052
Interactions between Cellulose Nanocrystals and Quartz: Adsorption and Wettability Studies	10.1016/j.colsurfa.2015.10.022
Amino-modified cellulose nanocrystals with adjustable hydrophobicity from combined regioselective oxidation and reductive amination	10.1016/j.carbpol.2015.09.089
Use of chemically modified nanocelluloses in flotation of hematite and quartz	10.1021/ie503415t
Physicochemical Properties of Aminated Butyl-Nanocrystals in Correlation to the Flotation Response of Quartz.	Accepted to IMPC 2016, Flotation: From Chemistry to Machines. Paper 719. Québec, Canada. 11th-15th September 2016.
Desenvolvimento de reagentes químicos´verdes´para flutuaçao de minerais	Indústriae Ambiente nº 86, may/june 2014. (Publindústria-EdiçõesTécnicas), nº 47 (ISSN 1645-1783)
Environmental risks of abandoning a mining project already started: Romaltyn Mining Baia Mare.	https://doi.org/10.1088/1757-899X/144/1/012004

❖ Project GEOSULF:

Title	Link (doi or similar)
Alkali activation as new option for gold mine tailings inertization	https://doi.org/10.1016/j.jclepro.2018.03.182
Utilization of sulphidic tailings from gold mine as a raw material in geopolymerization	10.1016/j.minpro.2016.02.012
Inertization of mine tailing via cold consolidation in geopolymer matrix	10.4028/www.scientific.net/KEM.761.31
Influence of sulphides on hydration of ground granulated slag alkali activated mortars and pastes	10.4028/www.scientific.net/KEM.761.92
Effect of metakaolinite on properties of alkali activated slag materials	10.4028/www.scientific.net/KEM.761.69
Influence of calcined mine tailings on the properties of alkali activated slag mortars	10.4028/www.scientific.net/KEM.761.83
Development and incorporation of lightweight waste-based geopolymer aggregates in mortar and concrete	10.1016/j.conbuildmat.2016.11.017
Mine tailings as a raw material for chemically bonded ceramics (CBC) – a review	10.1016/j.jclepro.2017.10.280

❖ Project SUSMIN:

Title	Link (doi or similar)
The use of low binder proportions in cemented paste backfill: Effects on As-leaching	Hamberg, Glenn, Maurice, Alakangas. Minerals Engineering 2015. Vol. 78. pp. 74-82. http://dx.doi.org/10.1016/j.mineng.2015.04.017
Treatment of arsenic-rich waters using granular iron hydroxides	Małgorzata Szlachta, Patryk Wójtowicz. Proceedings of 14th International Conference on Environmental Science and Technology, 2015; ISBN 978-960-7475-52-7
Treatment of arsenic-rich waters using granular iron hydroxides	Małgorzata Szlachta, Patryk Wójtowicz. Desalination and Water Treatment, 2016, vol. 57, no. 54, pp. 26376-26381
Sustainable treatment solution for arsenic-rich water from gold mines	Małgorzata Szlachta, Patryk Wójtowicz, Marzena Kozielec, Paweł Włodarczyk. Chapter in "Current issues in water treatment and water distribution"; Silesian University of Technology Press, 2016, pp. 93-99; ISBN 978-83-934758-5-8
Removal of arsenic (III) and arsenic (V) from water using material based on natural minerals	Małgorzata Szlachta, Patryk Wójtowicz. Proceedings "Arsenic Research and Global Sustainability, series Arsenic in the Environment"; CRC Press, 2016, pp. 480-481; ISSN 2154-6568
Adsorptive removal of arsenic species from aqueous solutions using granular ferric hydroxide (paper in Polish)	Małgorzata Szlachta, Patryk Wójtowicz. Ochrona Środowiska (Environmental Pollution Control), 2016, vol. 38, no. 4, pp. 47-52
Ferric hydroxide-based media for removal of toxic arsenic species: Kinetic, equilibrium and thermodynamic studies (paper in press)	Małgorzata Szlachta, Patryk Wójtowicz. Environmental Protection Engineering, 2018
Characterization of selected conservative and non-conservative isotopes in mine effluent and impacted surface waters: Implications for tracer applications at the mine-site scale	Larkins, C., Turunen, K., Mänttäri, I., Lahaye, Hendrikson, N., Forsman, P., Backnäs, S. Applied Geochemistry Vol. 91. pp 1-13. 2018. (In press) DOI: 10.17632/c5wk6nn4mp.1
Analyzing Contaminant Mixing and Dilution in Stream Waters influenced by Mine Water Discharges	Räsänen, T., Turunen, K., Hämäläinen, E., Hämäläinen, M., Backnäs S. 2018. Environmental Monitoring and Assessment 2018. (In Review)
Release of arsenic from cyanidation tailings	Hamberg, Glenn, Maurice, Alakangas. 2016. Minerals engineering. Vol. 93. pp 57-64. http://dx.doi.org/10.1016/j.mineng.2016.04.013

Lowering the water saturation level in cemented paste backfill mixtures – effect on the release of arsenic	R. Hamberg, C. Maurice, L. Alakangas. 2017. Minerals engineering. Vol 112. pp 84-91. https://doi.org/10.1016/j.mineng.2017.05.005
In-situ technologies for groundwater treatment: the case of arsenic	Marta I. Litter, José Luis Cortina, António M.A. Fiúza, Aurora Futuro & Christos Tsakiroglou. 2014. 208pp. In-Situ Remediation of Arsenic-Contaminated Sites, Chapter 1. ISBN 9780415620857
Arsenic Sorption by Iron Based Sorbents (IBS)	Fiuza, A., Futuro, A., Guimaraes, M. 2014. Chapter in Book: Book, One Century of the Discovery of Arsenicosis in Latin America (1914-2014). https://books.google.fi/books?isbn=1315778882
Arsenic removal using "green" Nano Zero Valent Iron	Fiuza, A., Futuro, A., De Lurdes, M., Vila, C., Rios, R. 2016. Chapter in Book: Arsenic Research and Global Sustainability DOI: 10.1201/b20466-233
Bromine leaching as an alternative method for gold dissolution	Rui Sousa, Aurora Futuro, António Fiúza, M.C. Vila, M.L. Dinis. 2018. Minerals Engineering. Vol 118, 16-23 pp. https://doi.org/10.1016/j.mineng.2017.12.019
Thiosulfate Leaching of the Auriferous Ore from Castromil Deposit – A Case Study	Rui Sousa, Aurora Futuro, António Fiúza. 2016. International Journal of Geological and Environmental Engineering. Vol 10. no3. http://scholar.waset.org/1999.6/10004104
Co-Disposal of Coal Ash with Mine Tailings in Surface Paste Disposal Practices: A Gold Mining Case Study	M. L. Dinis, M. C. Vila, A. Fiúza, A. Futuro, C. Nunes. 2016. International Journal of Geological and Environmental Engineering. Vol 10. no 7. https://waset.org/publications/10004915/co-disposal-of-coal-ash-with-mine-tailings-in-surface-paste-disposal-practices-a-gold-mining-case-study
Supergene gold enrichment in the Castromil-Serra da Quinta gold deposit	C. Cruz, F. Noronha, P. Santos , J.K. Mortensen and A. Lima. 2018. Mineralogical magazine. pp. 1-33. https://doi.org/10.1180/minmag.2017.081.063
Geophysics in gold exploration: some applications to northern Portugal gold deposits.	S. LEAL, R. MOURA, A. LIMA, A. PIVTORAK, D. RODRIGUES. SGEM2017 Conference Proceedings. Vol. 17, Issue 14, 147-156 pp. DOI: 0.5593/sgem2017/14/S05.019
Petrography and composition of white micas in the gold-	Cruz, C., Ribeiro, M.A., Noronha, F., Lima,

bearing system of Serra da Quinta (Paredes-Sobreira, Northern Portugal)	A. 2016. Comunicações Geológicas (2015) 102, Especial I, 23-26
Exploratory Leaching Tests of a Gold Ore	Carina Vicente 2014, Master in Mining and Geo-Environmental Engineering, FEUP
Alternative Reagents To Cyanide In Gold Leaching – A Case Study: Application Of The Ammoniacal- Thiosulphate System On Castromil Ores	Joana Silva Duerte 2015, Master in Mining and Geo-Environmental Engineering, FEUP
Conception of a system for treating gold ores by heap Leaching	Didacio Salema 2015, Master in Mining and Geo-Environmental Engineering, FEUP
Paste Co-deposition of gold ore tailings with incorporation of coal ashes	Carina Nunes 2015, Master in Mining and Geo-Environmental Engineering, FEUP
Sustainable strategies for tailings management of a gold mine project	Alejandra Lopez Sanchez 2015, Master in Mining and Geo-Environmental Engineering, FEUP
Waste management in the scope of a gold mine project - prediction of acid drainage and study of mitigation solutions	Antonio Fernandez 2016, Master in Mining and Geo-Environmental Engineering, FEUP
Mapping hydrothermal gold mineralization using Landsat 8 data. A case of study in Chaves license, Portugal.	Rui Frutuoso 2014, Geology FCUP
Gold mineralizations in Ponte da Barca licence	Filipe Valente 2015, Geology FCUP
Análise Espacial das Mineralizações de Antimónio em Relação com Magmatismo Básico Filoniano e Outras Características Geológicas no Distrito Auri - Antimonífero Dúrico - Beirão	Adriana Silva 2016, Geology FCUP
Propriedades Magnéticas relacionadas com as alterações hidrotermais associadas a mineralizações de Au intragraníticas	Ana Gonçalves 2016, Geology FCUP
Supporting water management strategies in gold mining using ecological risk assessment.	Malinen, M. 2015. http://urn.fi/urn:nbn:fi:uef-20160263
Effects of the Treated Drainage and Process Water in the Water System below the Kittilä Mine.	Hämäläinen, M. 2015. Savonia University of Applied Sciences. (In Finnish) http://www.theseus.fi/handle/10024/96331
Impact of Water Balance and Flow Profile on Mixing and Diluting Substances in the Recipient River of Kittilä Mine.	Hämäläinen, E. 2015. Savonia University of Applied Sciences. (In Finnish) https://www.theseus.fi/handle/10024/91769