**Brief information about the project**

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| Name of the project | AP19178184 «Study of REE concentration processes from products of supercritical CO2 conversion of Kazakhstan phosphogypsum» |
| Relevance | The proposed project is aimed at investigation of sc-CO2-conversion processes followed by concentration of REEs from the obtained products. Integration of high-efficiency supercritical technologies into the process of complex processing of waste PG contributes to the development of a waste-free, cost-effective technology. The project aims to solve several problems at once: utilization of large-tonnage phosphorus waste, which is detrimental to the ecology of the region; obtaining rare-earth concentrate from secondary raw materials, which in the future will make it possible to obtain individual rare-earth elements. This project is a continuation of research in this area. |
| Purpose | Optimization of the process of sc-CO2 conversion of waste phosphogypsum with further concentration of REEs from the obtained products |
| Objectives | 1) study the qualitative and quantitative composition of the feedstock – dumped phosphogypsum;<br><br>2) purification of phosphogypsum from water-soluble impurities, mainly phosphate ions and fluorine;<br><br>3) Optimization of the conversion process of washed phosphogypsum in supercritical carbon dioxide from 87 to 99%;<br><br>4) development of methods of REE concentration from calcium carbonate. |
| Expected and achieved results | - physical and chemical characteristics of the initial raw material - dumped phosphogypsum will be studied by methods of mineralogical, X-ray phase analysis, by scanning electron microscopy, and the amount of fluorine-, phosphate- and sulfate-anions will be determined by gravimetry, potentiometry and elemental quantitative chemical analysis methods;<br><br>- Phosphogypsum will be cleaned to remove water-soluble impurities as much as possible;<br><br>- Optimizing the conversion process of washed phosphogypsum in sc-CO2;<br><br>- leaching of REE ions from obtained calcium carbonate by different mixtures of mineral and/or organic acids, as well as their mixtures will be selected as optimal mode;<br><br>- concentration of REE ions from leaching solutions of calcium carbonate obtained by sc-CO2 conversion of Kazakhstan PG will be carried out.<br><br>By the end of the project at least two (2) articles will be published in journals of the first three quartiles of the impact factor in the Web of Science database or having a CiteScore percentile in the Scopus database of at least 50.<br><br>The following results achieved during the implementation of the project in 2023:<br><br>Procurement of materials and delivery of the initial raw material - a general sample of waste phosphogypsum with a total mass of 20 kg. Sample preparation of the obtained |

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| | sample was carried out. The general sample was dried for 24 hours at a temperature of 100 - 105 ºC. Grinding and reduction was carried out by quarting, ring and cone methods. Selection of analytical samples was carried out by staggered selection method. Samples were analyzed for the content of the target group of rare earth metals and macrocomponents by X-ray phase analysis, SEM, ICP-MS and atomic absorption spectroscopy.<br><br>Purification of the general sample of phosphogypsum from water-soluble impurities was carried out, and purified phosphogypsum was prepared for conversion under Sk-CO2 conditions. During the experiments it was found that the content of all water-soluble phosphates (hydrophosphates, dihydrophosphates) is 39.4% and fluorine 12% of their total content in the initial form of phosphogypsum. The content of fluoride ions was controlled by ionometry method, the content of phosphates - by magnesia gravimetric method. As a result of a series of experiments on phosphogypsum conversion, a model describing the influence of controlled process parameters on the degree of conversion of calcium sulfate to calcium carbonate was constructed. The model is described by the equation Y = 34.66 - 4.8X3. It is found that the most influential factor is the T:L ratio in the system. It is also found that the optimum pressure range in the system is 50-65 atm. At its further increase the degree of conversion does not increase significantly. By steep ascent method, the model was optimized, the conversion rate increased from 85 to 90% under the following conditions: t = 15 min, T = 33 ℃, P = 55 atm, CO2 flow rate = 800 -1200 g/min. |
| Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles | Tamina Narimanovna Khavaza<br><br>Hirsch Index - 3<br>1) Author ID Scopus – 57345081100 (https://www.scopus.com/authid/detail.uri?authorId=57345081100 )<br>2) Researcher ID in WoS GEW-4233-2022 (U-2267-2017 https://www.webofscience.com/wos/author/record/30114620 )<br>3) ORCID ID 0000-0002-1614-3060 (https://orcid.org/0000-0002-1614-3060 )<br>Nauryzbayev Mikhail Kasymovich, Doctor of Technical Sciences, Professor, Academician of KazNANS.<br>Hirsch Index - 9 (Scopus).<br>1) Web of Science Researcher ID - D-3432-2012 https://www.webofscience.com/wos/author/record/180447,1093398,27160849<br>2) ORCID: 0000-0002-6781-6464 https://orcid.org/0000-0002-6781-6464<br>3) Scopus ID: 6506602038 https://www.scopus.com/authid/detail.uri?authorId=6506602038 |
| List of publications with links to them | - |
| Patents | - |

Plow dumps of phosphogypsum from Kazphosphate LLP, Zhambyl region RK (30 million tons)

**Plow phosphogypsum dumps Kazphosphate LLC Zhambyl region, RK (30 million tons)**

**Reduced PG Sample CaSO4 ×2H2O Fraction x≤0,056 mm.**

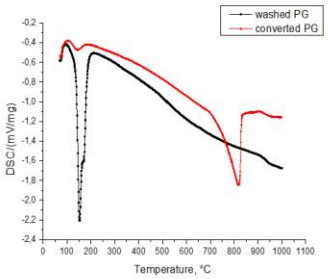
**Washed and dried PG Sample $CaSO_4 \times 0{,}5H_2O$**

**scCO2 conversion process**

$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4 + Q$

$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2 + Q$

**Converted PG Sample to $CaCO_3$**




**Converted PG Sample TGA**