Scientific report for the II. period

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 4

Title	„Studies of mineral resources- the new products and technologies" (Zeme) [Earth]		
Project leader's name, surname	Valdis Seglins		
Degree	Dr. geol.		
Institution	University of Latvia		
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2.2. Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

Overall objective for the project the Second phase is to perform the studies of mineral resources (mainly clay, dolostone, peat and gyttja) and develop experimental and analytical part of the project.

Project goal and objectives	Major results
1. Study Latvia mineral resources (mainly clays, dolostone, peat and gyttja) and evaluate resources diversity and potential use for industrial production	Studies covered quite wide spectrum of mineral resources, but mainly dolostone and peat. Separate study subject were sand and clay and recognition of deposits location regularities. Duding the study expanded geophysical research was developed to reach practical and applied results. Results are successful in particular regarding methodology, results are published and most of these results are delivered to the private sector companies to be tested and verified.
2. To investigate treatment, preparation and modification possibilities of Latvian clays for development of new technologies and innovative products with high added value for application in cosmetics and improvement of environmental quality (innovative sorbents and biodegradable polymers).	Investigation of clay properties for application in sunscreens, stabilization of emulsions and development of biodegradable composite materials and innovate granular sorbent. To investigate treatment, preparation and modification possibilities of Latvian clays for development of new technologies and innovative products with high added value for application in cosmetics and improvement of environmental quality

	(innovative sorbents and biodegradable polymers).
3. Development of low temperature ceramic materials using mineral raw materials of Latvia.	During the 2nd period of Program implementation three major studies were perform: • determination of mechanical properties of clay-dolomite porous ceramic; • preparation of nano-level powders for surface modifications of various substrates; • preparation of Prometejs clays for infusion with ashes from "Sakret" in order to develop low-temperature ceramics. To determine and limit the choice of perspective mineral raw materials to use for development of ceramic products Most of results have been summarised in papers and presented at scientific conferences.
4. The project goal was obtaining of highly porous clay and oxide ceramics, determination of sorption properties and possible practical use of these ceramics.	1. Investigation of thermal, physical and chemical processes during firing of various clays and oxides; 2. Determination of pores structure of obtained materials by mercury porosimetry and nitrogen absorption (BET). 3. The possible use of some organic by-products for the increasing of surface area and porosity of ceramic materials. 4. Determination of sorption ability of such materials concerning to some organic and inorganic pollutants in the water. 5. Investigation of various surface activation with task to increase a sorption ability or photocatalytic activity of materials. 6. Determination of filtering properties and sorption ability of highly porous ceramics
5. The aim of the sub-project is to study peat and sapropel (organogenic deposits) properties, their relations to diagenetic transformation processes of natural	The worktasks of the 2.nd period of the project includes sampling of Jurassic and other clay samples, sample modification and studies of properties of the obtained,

organic matter as well as to study their application potential.	characterization of their properties by means of different methods and relations to application options. The indirect aim of the research is related to environmental remediation possibilities, both in respect to dredging of eutrophic lakes and complex use of clay, peat and sapropel to develop added value products.
6. To immobilize and study the activity of microorganisms in biopreparations for agricultural and environmental biotechnologies	Immobilization of *Streptomyces griseoviridis* and *Azotobacter* sp. took place in all the carriers, but more bacteria bound to the peat. Interactions of *Trichoderma* spp. in soils with biochars differed by feedstock and particle size were studied. Both studies were successful.

2.3. Description of gained scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

The project was organized as integrated study between 6 research groups from several institutions (mainly University of Latvia and Riga Technical University) coordinated in manner from bottom to up-- in particular conditions-- from geological basic studies to intense microbiological studies. The following will shortly describes major results of particular subprojects.

1. **Mineral resources studies**. Studies covered quite wide spectrum of mineral resources, but mainly dolostone and peat. Separate study subject were sand and clay and recognition of deposits location regularities. In details studied dolostone characteristics and resources resultes in scientific monograph of A. Stinkule and Ģ. Stinkulis leading to future research for commercial sector directly. Specific attention include properties of dolostone, technological properties and conditions for processing , but mostly geological regularities of certain properties deposits locations. This were expanded in doctoral thesis of D. Pipira

Late Quaternary natural conditions were studied in details and are number of new regularities for these mineral resources prognosis and search are available because of doctoral thesis protected by K. Lamsters and most of these knowledge are summarised in his scientific monograph. Besides L. Zarina doctoral thesiss were addressed to studies in details of chert and flint.

During the study expanded geophysical research was developed to reach practical and applied results. Results are successful in particular regarding methodology for applied geological field studies, mostly for road constructions and quality control. Study scientific results are published and most of these results are delivered to the private sector companies to be tested and verified. Most of results are summarised in J. Karušs doctoral thesis and scientific monograph.

Evaluated indirect geological research methods (geophysical studies) in particular for applications to peat studies to reach instrumental qualities of data and there is

possibilities to develop the method during the second phase of the project to finalise with methodology of this method

2. Studies about clay properties for applications in cosmetics and materials for environmental quality improvement. Research show that it is possible to obtain homogeneous and dense clay microspheres with rough surface by using spray dryer. It was concluded that the air pressure in spray nozzle has the greatest effect on the size of microspheres, while the other investigted parameters has a relatively small influence. Surface roughness of spray-dried granules depends on clay composition.

Brown colour clay powder (fraction under 2 μm) was used to make sunscreens with natural ingredients. The addition of clay powder obtained with the spray dryer provided much better homogeneity of the sunscreens than by using clay powder obtained by mechanically chrushing the clays in a pestle. Therefore the suncreens applied on the skin did not leave any visible clay aggregates. The sunscreens contained 5, 10 and 15 mass% of clay fraction and the obtained SPF (sun protection factor) was 0.8, 1 and 1.4, respectively.

The scientific research about the stabilization of emulsions showed that the addition of Latvian illitic clays (fraction under 2 μm) improve the stability of emulsion oil-in-water, therefore obtaining Pickering emulsion. The higher the viscosity of the Pickering emulsion, the more stable the emulsion became. The most stable emulsions were obtained by adding clay powder with the highest amount of clay minerals and also by increasing the added amount of the clay podwer (10 mass%). Emulsions with pH 5,5 were more stable than emulsions with pH 7-8.

A number of biodegradable composite materials with 1-20 mass% of Latvian illitic clays were developed. Viscosity of the composite materials increased noticeably by addition of more than 10 mass% clay. Experiments showed that to obtain the necessary layer consistency less than 7 mass% of clays is needed. The development of homogenous layer is affected by the hydrophobic properties of the composite material ingredients – only few contents of the obtained composite materials with added clay particles made homogenous cover layer.

Sorption properties of the clay containing hollow sphere granules were investigated. Granules calcined at 1000°C showed the highest ability to adsorb organic compounds, for example, adsorption of diesel fuel and gasoline was 0.30±0.002 and 0.29±0.007 g/g, respectively. Slightly lower adsorption was observed towards organic solvents toluene and hexane – approximately 0.24 g/g. The maximum adsorption capacity of the granules is obtained in the first 5 minutes of the sorption experiment. Granules calcined at 1100°C showed the lowest adsorption ability – the adsorption of these granules did not exceed 0.2 g/g (adsorption of toluene).

3. Ceramics studies. Overall, the goals and tasks of 2nd period have been performed. Main scientific and practical conclusions, which are directed towards /relatively/ new products and development of according laboratory technologies (methods), are as follows:

By using quartz sand of Bāle query, two types of clay (Nīcgale and Ugale deposits) in mixes with synthetic additives of Al(OH)3 and Mg(CO3) a pore containing (pore volume about 50%) high-temperature cordierite thermal shock resistant material has been developed by using traditional sintering method.

During report period the thermal shock resistance of samples of various compositions have been determined by controlling it with measurements of modulus of elasticity after 10 thermal shock cycles in temperature range of 800-1000/20 °C. It has been shown that untreated sample modulus of elasticity is high and within range of 55-98

GPa. After 10 thermal shock cycles these values drop by about 50-70% but remain constant throughout whole thermal cycling period. Final values do not drop below acceptable limit. It means that the developed porous ceramic material has self-repairing ability throughout the whole thermal cycling period which is enabled by presence of viscous liquid phase which upon cooling fills-in possibly formed cracks and other defects.

By continuing work with 2:1 layered mineral – illite structure modification intended to transform octahedral AlO_6 layer which is entrapped between two SiO_4 layers into 4-coordinated Al-ion state, and formation of uninterrupted Al-O-Si polymeric (amorphous) activated structure which would allow the formation of low-temperature geopolymers. It has been recognized that various concentration alkali (KOH or NaOH) influence on illite destructuring is limited and pronounced Al-ion tendency to form new polymeric amorphous structure with Si- ion has not been observed. Both alkali and illite thermal treatments at ~600 °C mainly influences on the OH- Al bonds in illite structure, as well as with so-called illite structural water which is loosely connected with the structure of illite. In any case, such treated illite clays are considered to be activated which results in lowering of firing temperature by about 150-200 °C.

In compositions with 20-50% of Al(OH)3 they form dense, various colour palette (depending of amount of Al(OH)3) ceramic materials. Fired samples are characterized with 2,2 – 2,5 g/cm3 density and high compressive strength – about 170 N/mm2. As it was mentioned in previous report and as the additionally obtained data are showing, these materials can be used as both durable (long-term) flooring material and in construction in general as construction element in buildings, including the bearing load parts. By taking into account the colouring of the material which is from bright red-brown to yellowish-brown, nano-powder particles prepared in 2nd work period could be used in preparation of refractory paints.

Two-component 10 homogenized mixes from clay raw materials (Nīcgale and Apriķi query) and JSC “Sakret” manufacturing leftovers – shale ash have been prepared in mass relations 1:1, 1:2 and 1:3. The chemical composition of ashes as well as phase transitions during heating process has been determined.

4. Highly porous ceramics with activated surface.

Overall, the goals and tasks of 2nd period have been performed. Main scientific and practical conclusions could be summarized as follows: 1.Obtained materials characterises with selective sorption ability concerning some inorganic and organic water pollutants. Sorption ability depends on the more factors such as chemical and mineralogical composition of raw clays, sintering temperature and conditions, extra treatment of surface of sorbent, e.g., nanodisperse coating or irradiation with accelerated electrons; 2. An extra addition of glycerine (by-product by refinement of rape oil) improves the pore structure and sorption ability of ceramic granules. Ceramic pellets obtained from such ceramic mass show better sorption ability in comparison with pellets obtained from ceramic mass with additive only saw dust (report after the first period of project); 3. The same material depending on the chemical and mineralogical composition and sintering temperature can influences the pH of sorption medium and influences a sorption ability; 4. Nano disperse silicon containing additives decreases an anisotropy of mechanical strength of highly porous alumina ceramics in result of formation of small mullite crystals; 5. Highly porous oxide ceramic on the basis of phyllosilicate (talcum) is obtained and ceramic properties and phase composition is determined.

5. The peat, gyttja, clay properties and possible modification studies.
Within the second year of the project extensive field sampling of materials for furher studies were done. For characterisation of full sample profiles besides to their dating, biological composition, pollen analysis, also multiproxy physical and chemical analysis were done including for example elemental analysis (C, H, N, O, S, metal concentration (18 metals), spectroscopic analysis (UV-Vis, FTIR, Fluorescence spectra, fluorescence 3D EEM, ^{13} C NMR, ^{1}H NMR etc). Clay samples were characterised using relevant techniques. Novel approaches has been elaborated to develop new clay based sorbents for removal of metalloids and phenolics. The sorption models as well as kinetics were studied. The results were obtained using batch tests and the sorption was studied as a function of initial metalloid concentration, pH, sorption time as well as presence of competing substances. Obtained results indicate that modification of peat with Fe compounds significantly enhance the sorption capacity of the sorbents used for sorption of arsenic, antimony and tellurium. The optimal pH interval for the sorption of Sb(III) is 6.5–9 and for As(V) and Sb(V) – 3–6 of, while As(III) and tellurium sorption using Fe-modified peat is favourable in a wider interval of 3–9. The presence of competing ions as well as HA affect sorption of metalloids on Fe-modified peat. Minor impact on the reduction of metalloid sorption was detected at the presence of nitrate, sulphate, carbonate and tartrate ions, while in the presence of phosphate and HA sorption ability of metalloids can be considerably reduced. Obtained results of kinetic experiments indicate that sorption of metalloids on Fe-modified peat mainly occurs relying on mechanisms of physical sorption processes.Multiproxy approach on analysis of peat and lake sediments to characterise humification conditions has been applied for first time and obtained results support further studies on application potential of sedimentary material.

4.6. Microbiological studies. Thre are 2 studies performes.
Floating biopreparations for hydrocarbon degradation in water.
Ceramic granules fabricated from Quaternary clay at 1200 °C with density 0.95 g cm^{-3}, were tested for their flotation ability in the synthetic wastewaters containing silicone oil. The presence of oil in the liquid phase improved granules' flotation, probably due to sorption of oil by ceramics. Coating of granules by SiO_2 resulted in a decreased flotation ability, irrespectively of the presence of oil. Granules were shown to be appropriate for bacterial colonization.
Immobilized active compounds for microbial biofertilizers.
Immobilization of *Streptomyces griseoviridis* and *Azotobacter* sp. took place in all the carriers, but more bacteria bound to the peat. Both the carrier material and storage temperature affected bacterial viability. It is recommended to store immobilized *S. griseoviridis and Azotobacter* sp. products in the peat at room temperature (20 °C) and -18 ° C, respectively. In the case of bacterial immobilization in the ceramic granules, it is recommended to store microbial preparations at a low temperature, i.e., -18 °C. Bacterial suspensions in sterile water can be stored at 4 °C for at least 10 months.
Interactions of *Trichoderma* spp. in soils with biochars differed by feedstock adn particle size were studied. This study was aimed at comparing the effect of *Trichoderma viride* alone and in the presence of 3% wood- or straw-derived biochar on the growth of rye *Secale cereale* L. (sandy soil, in pots) and corn *Zea mayze* (loamy-sand soil, mini-field experiment), respectively. Seed germination as well as

the growth and development of seedlings were monitored. Fungal abundance in soil samples was estimated with emphasis on the prevalence of *Trichoderma* spp. in *Trichoderma*-amended soils. Experiments with corn demonstrated a stimulating effect of treatments to the plant growth in comparison with untreated soil, in the following order: [*Trichoderma viride*]>[*Trichoderma viride*+straw biochar]>[Straw biochar]. Biochar addition resulted in a considerable decrease of the percentage of saprophytic fungi. Corn and rye seed germination was faster in the presence of both biochar types tested in this study, irrespectively of different soil types and other experimental conditions.

2.4. Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

Future research activities in general will continue recent studies to evaluate natural diversity of Latvia mineral resources taking on account possibilities to utilize these knowledge in new technologies and products with specific attention to clay and peat modifications.

In respect to geological studies major attention will be concentrated on Quaternary geological deposits forming regularities (deglaciation models developed) to reach suitable clay and sand deposits as raw material for new technologies and products. Therefore corresponding field and sampling activities for test material collection will be performed for studies in the 3 other research groups of this project. As important task is to develop geophysical methods (georadar) suitable for instrumental accuracy regarding depth of peat deposits and applications to road construction geotechnical studies in details.

Further research will be aimed to evaluate the effect of the suspension stability on the morphology of the obtained clay granules and the ability to resu-spend after the spray drying. The obtained granules will be used to continue developing sunscreen with higher SPF than the present sunscreen. Research about the stabilization of emulsions with clay addition will be continued by using emulsions with less oil phase in the emulsion and by making the Pickering emulsions in higher temperatures. Development of biodegradable cover material layer will be continued and effect of the added clay amount on their physical properties will be researched. Acquirement and investigation of organic compound sorption properties of clay containing porous sorbent by using combine method will be carried out.

Further directions of research regarding highly porous clay and oxide ceramic will be following: 1. Evaluation the effect of other pore forming additives on sorption properties of clay ceramic pellets; 2. Study of nanodisperse coatings which should provide the photocatalytic activity of the investigated materials especially when particles are obtained during thermal treatment of coated ceramic pellets; 3. Highly porous clay and oxide ceramic obtained by different pore formation methods create an interest as ceramic filters.

Regarding development of ceramics studies is concluded, that future development of the study will continue to concentrate on (a) enlargement of the basis of illite clays suitable for ‘geopolymer’ synthesis to obtain materials with relative low temperatures and higher possible compressive strength; (b) using of mixes from different clays and fly ashes to reduce the global warming potential and impact of by-products (fly ashes)

on environment; (c) functionalizing of different substrates (e.g., cellulose fibers) by clay or clay mineral – illite nanoparticle deposition to improve, e.g., its resistance to temperature; (d) use of organic templates (e.g. wood) to reproduce its unique morphology to obtain new ceramic materials, for example, for medicine.
Study continuation will include clay modification options, studies of humic substances isolated from peat and sapropel, their structure, as well as their application possibilities.
Regarding development of microbiological studies the scheme of further experiments can be modified by shortening the retention time of wastewater in the columns as well as optimizing the "beads : liquid phase" ratio. In respect to f nitrogen-fixing bacteria used in agriculture as a biofertilizer to stimulate the plant growth further study is necessary to test the developed biopreparations under field conditions.

2.5. Dissemination and outreach activities
(Describe activities that were performed during reporting period to disseminate project results)

Research about the project was disseminated to the public in two scientific conferences and one symposium - The 10th International Scientific and Practical Conference "Environment. Technology. Resources." (2015, June 18-20, Rezekne, Latvia), Riga Technical University 56th International Scientific Conference (2015, October 16, Riga, Latvia) and I International and Interdisciplinary Symposium "Clays and Ceramics" (2016, January 28-29, Riga, Latvia).
Most of outreach activities are coming out from mineral resources in general and water resources are well known by publications in National newspapers and popular scientific magazine "Ilustrēta Zinātne".
Specifically should be mentioned traditional dr. R. Svinka cooperation and scientific expertise in development and evaluation of pupils (Secondary School grade) scientific works usually related with mineral resources, chemical and technological processes.

Most of scientific results are published, including 7 articles (*SCOPUS*, SNIP > 1) and 2 articles included in ERIH (A+B), 13 in EBSCO, VINITI, Chemical Abstracts databases. Results are presented in 4 original scientific monographs, and most of the program 1st stage research results are concentrated in 5 protected doctoral thesis.
As particular high rate should be recognized in respect to participation in International scientific conferences (10 conferences and abstracts are published), and there are number of participations National scale Scientific conferences (2 presentations performed with published abstracts) with participation of project social partners from industry.
Besides developed new research methods and methodology.

Appendix

Scientific results

Scientific publications

Original scientific papers (*SCOPUS*) (SNIP > 1)

1. J.Burlakovs, F.Kaczala, K. Orupold, A.Bhatnagar, Z.Vincevica-Gaile, V.Rudovica, M.Kriipsalu, M.Hogland, M.Stapkevica, W.Hogland, M.Klavins (2015) Field-portable X-ray fluorescence spectrometry as rapid measurement tool for landfill mining operations: comparison of field data vs. Laboratory analysis. International Journal of Environmental Analytical Chemistry, DOI: 10.1080/03067319.2015.1036865 IF 1.295 http://www.tandfonline.com/doi/abs/10.1080/03067319.2015.1036865

2. M.Klavins, J.Burlakovs, R.Ozola, O.Muter (2015), Composite clay sorbents for immobilisation of biomolecules and cells. Journal of Biotechnology, 208, S56 http://findresearcher.sdu.dk/portal/en/publications/the-role-of-governance-in-realising-the-transition-towards-sustainable-societies(0c4e2eab-b116-4a16-b0e1-60b4ae482d3d).html

3. W.L.Filho, J.Platje, W.Gerstberger, R.Ciegis, J.Kaaria, M.Klavins, L.Kliucininkas (2015) The role of governance in realising the transition towards sustainable societies. Journal of Cleaner Production, DOI: 10.1016/jclepro.2015.11.060 http://www.sciencedirect.com/science/article/pii/S0959652615017254 IF 4.167

4. L.Klavins, L.Klavina, A.Huna, M.Klavins (2015) Polyphenols, carbohydrates and lipids in berries of Vaccinium species. Environmental and Experimental Biology, 13, 147-158 http://eeb.lu.lv/EEB/current/EEB_13_Klavins.pdf

5. I.Sperberga, M.Rundans, A.Cimmers, L.Krage, I.Sidraba. Mechanical properties of materials obtained via alkaline activation of illite-based clays of Latvia. 2015, IOP Conf.Series: Journal of Physics, 602. http://dx.doi:.10.1088/1742-6596/602/1/012007 (SCOPUS) http://www.sciencedirect.com/science/article/pii/S0272884215010603

6. I.Zake-Tiluga, V.Svinka, R.Svinka, L.Grase. Thermal shock resistance of porous Al2O3-mullite ceramics. Ceramics International, 2015, vol. 41, pp. 11504–11509. ISSN 0272-8842. doi:10.1016/j.ceramint.2015.05.116 (SCOPUS)

7. I.Zake-Tiluga, V.Svinka, R.Svinka, B.Ziehrat, P.Greil, T.Fey. Thermal Conductivity and Microstructure Characterisation in Lightweit Alumina and Alumina-Mullite Ceramics. J.Eur.Ceram.Soc. 2016, vol.36, iss.6, p.1469-1477 (SCOPUS).
http://www.sciencedirect.com/science/article/pii/S0955221915302855

Original scientific papers *ERIH* (A and B) database included

1. I.Dušenkova, I.Kusiņa, J.Mālers, L.Bērziņa-Cimdiņa. Application of Latvian illite clays in cosmetic products with sun protection ability. *Proceedings of the 10th International Scientific and Practical Conference "Environment. Technology. Resources.",* 2015, Vol.I, 28-32.
Available at: http://journals.ru.lv/index.php/ETR/article/view/203/607

2. A.Stunda-Zujeva, V.Stepanova, L.Bērziņa-Cimdiņa. Effect of spray dryer settings on the morphology of illite clay granules. *Proceedings of the 10th International Scientific and Practical Conference "Environment. Technology. Resources."*, 2015, Vol. I, 216–222.
Available at: http://journals.ru.lv/index.php/ETR/article/view/200/642

Original scientific papers in other data bases (EBSCO, VINITI, Chemical Abstracts):

1. Diāna Dūdare, Māris Kļaviņš (2015) Chemical Element Accumulation in Peat and Its Humic Substances. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, pp. 53-57.
Available at: https://ortus.rtu.lv/science/lv/publications/21544

2. J. Burlakovs, R. Ozola, J. Kostjukovs, I. Kļaviņš, O. Purmalis, M. Kļaviņš (2015) Properties of the Jurassic Clayey Deposits of Southwestern Latvia and Northern Lithuania. Material Science and Applied Chemistry, 32, 5-12
Available at: https://ortus.rtu.lv/science/lv/publications/20935

3. Muter O., Limane B., Strikauska S., Klavins M. 2015. Effect of humic-rich peat extract on plant growth and microbial activity in contaminated soil. Scientific Journal of RTU: Materials Sciences and Applied Chemistry, 32: 68-74. doi: 10.1515/msac-2015-0012
Available at: https://ortus.rtu.lv/science/lv/publications/21546

4. 2.Muter O., Bērziņš A., Selga T., Švinka V. Floating ceramics vs floating oils: search for appropriate conditions. Submitted (Scientific Journal of RTU: Materials Sciences and Applied Chemistry). February, 2016.
Availble as file in deliveries.

5. Dokukins E., Muter O. Comparison of paraffin and diesel as cultivation medium supplements for preparing a hydrocarbon-degrading bacterial biomass. Submitted (Scientific Journal of RTU: Materials Sciences and Applied Chemistry). February, 2016.

Available as file in deliceries.

6. Žvagiņa S., Petriņa Z., Nikolajeva V., Lielpētere A. Immobilization and survival of root nodule bacterium Rhizobium leguminosarum biovar viciae. Material Science and Applied Chemistry, 2015, 32, 75-79. doi:10.1515/msac-2015-0013
Available at: https://ortus.rtu.lv/science/lv/publications/21549

7. M.Rundans, I.Sperberga. Porous cordierite ceramics from natural clays. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, 33-38.. http://dx.doi:10.1515/msac-2015-0006 (EBSCO, ProQuest, VINITI, Chemical Abstracts)
Available at: https://ortus.rtu.lv/science/lv/publications/21540

8. G.Sedmale, M.Randers, L.Grase, J.Kostjukovs. Use of differential treatment of illite to modify their structure and properties. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, 19-22. http://dx.doi:10.1515/msac-2015-0003 (EBSCO, ProQuest, VINITI, Chemical Abstracts)
Available at: https://ortus.rtu.lv/science/lv/publications/21484

9. G.Sedmale, I.Raubiska, A.Krumina, A.Hmelov. Effect of illite clay additive on sintering, phase composition and properties of mullite-ZrO2 ceramics. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, 27-32. http://dx.doi:10.1515/msac-2015-0004 (EBSCO, ProQuest, VINITI, Chemical Abstracts)
Available at: https://ortus.rtu.lv/science/lv/publications/21485

10. I.Sperberga, P.Spela, M.Rundans, A.Cimmers. Chemically and thermally activated illite clay from Latvia. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, 27-32. http://dx.doi:10.1515/msac-2015-0005 (EBSCO, ProQuest, VINITI, Chemical Abstracts)
Available at: https://ortus.rtu.lv/science/lv/publications/21486

11. Ruta Švinka, Visvaldis Švinka, Inga Pudže,Mārīte Damberga 2015 Clay Ceramic Pellets for Water Treatment. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, 39-44.
Available at: https://ortus.rtu.lv/science/lv/publications/21541

12. Olita Medne, Rita Seržāne, Līga Bērziņa-Cimdiņa 2015 Composition of Alternative Daily Cover Materials with a Perspective of Use of Latvian Local Resources. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, 45-48.
Available at: https://ortus.rtu.lv/science/lv/publications/21542

13. Daiga Pipira, Juris Kostjukovs, Ģirts Stinkulis 2015 Mineral Composition and Morphology of Dolocretes of the Devonian Burtnieki and Amata Formations, Latvia. RTU zinātniskie raksti, Materiālzinātne un lietišķā ķīmija, 2015, 32, 13-18.
Available at: https://ortus.rtu.lv/science/lv/publications/21483

Original per reviewed scientific monographs

1. Karušs, J. Ģeoradara izmantošana ceļu seguma un ceļu uzbēruma izpētē. Rīga : LU, 2015. 41 lpp.
Availabe as book in deliveries.

2. Stinkule, A., Stinkulis, Ģ. Latvijas devona dolomīti. Daugavpils Universitātes izdevniecība "Saule", 2015, 80 lpp.
Availabe as book in deliveries.

3. Karušs, J. Ģeoradara izmantošana purvu nogulumu pētījumos. Latvijas Universitāte, LU Akadēmiskais Apgāds, 2015, 136 p.
Availabe as book in deliveries.

4. Lamsters K. Zemgales ledus loba subglacialās reljefa formas un to uzbūve. Latvijas Universitāte, LU Akadēmiskais Apgāds, 2015, 157 p.
Availabe as book in deliveries.
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Developed new methods and methodologies

Protecteds doctoral Thesis

1. Karušs Jānis Radiolokācijas metodes izmantošana purvu nogulumu pētījumos, aizstāvēts 2015. gadā
Available at:
http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/zinas/Disertacija_Janis_karuss.pdf

2. Lamsters Kristaps Fenoskandijas ledus vairoga Zemgales loba subglaciālā reljefa sistēmas un dinamika, aizstāvēts 2015. gadā.
Available at:
http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/zinas/Prom-kops_Lamsters_Kristaps__final.pdf

3.Pipira Daiga Subaerālās atsegšanās notikumu pazīmes un veidojumi devona slāņkopā , aizstāvēts 2015. gadā
Available at:
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3. New technologies, methods, prototypes etc.
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