



Institute of Geotechnics

Slovak Academy of Sciences



Assessment period

2012 – 2015

Outline

- Introduction of IGT SAS
- Principal activities of research departments
- Research projects, national and international position
- Research outputs (publications, citations)
- PhD study
- Social impact
- Management
- Research strategy and future development



Institute of Geotechnics SAS - established in 1954

Current research activities of IGT SAS issue from the Institute's tradition related to the mining activities in Slovakia strongly connected to **mineral exploitation, processing and beneficiation of raw materials.**

After the regression in mining industry in 1990s, the IGT SAS has begun the transition to the new research activities.

Research areas of IGT SAS

- rock cutting and drilling, TBM tunnelling,
- mineral processing by physical, chemical and biotechnological methods,
- mechanosynthesis and mechanochemical activation of minerals and materials,
- (nano)materials development for environmental applications,
- mineral and environmental biotechnologies and nanotechnologies
- remediation and recovery of mining and industrial areas,
- water and soil clean-up,
- industrial waste treatment.

Director

Dr. S. Hredzák

Deputy Director

Prof. V. Krúpa

Scientific Secretary

Dr. M. Václavíková

Scientific Board
with external members

Institute Board

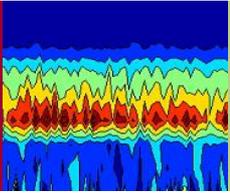
Administration Unit

4 persons

Library

1 person

Scientific Departments of the Institute of Geotechnics SAS



Department of Destructional and Constructional Geotechnics

Dr. Milan Labaš



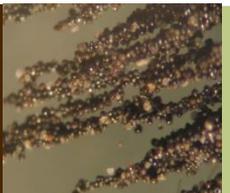
Department of Physical and Physico-Chemical Mineral Processing Methods

Dr. Anton Zubrik



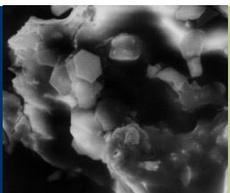
Department of Mechanochemistry

Dr. Zdenka Bujňáková



Department of Mineral Biotechnologies

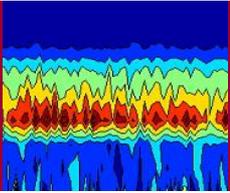
Dr. Daniel Kupka



Department of Environment and Hygiene in Mining

Dr. Jozef Hančulák

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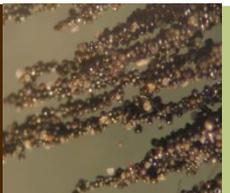
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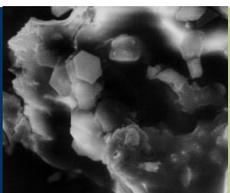
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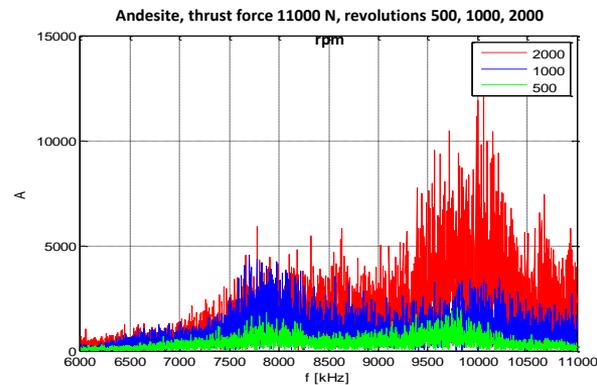
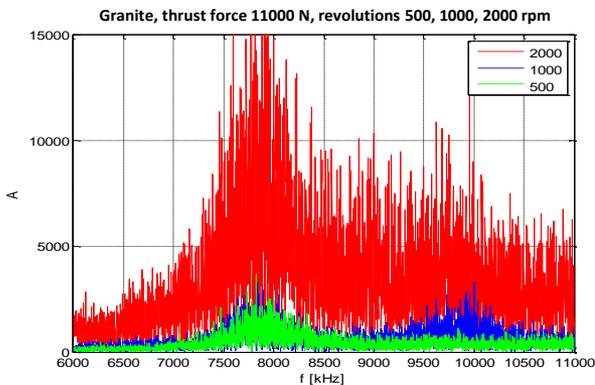
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Research activities

Rock Drilling & Vibrations

- ✓ measuring chain = experimental laboratory drilling rig + vibration accelerometers + dynamometer
- ✓ analysis of induced vibrations in rock drilling for monitoring and optimization of rock drilling process
- ✓ search for specific patterns in vibration signal identification of rock types

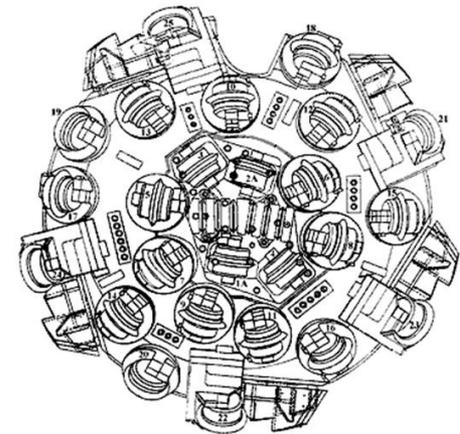
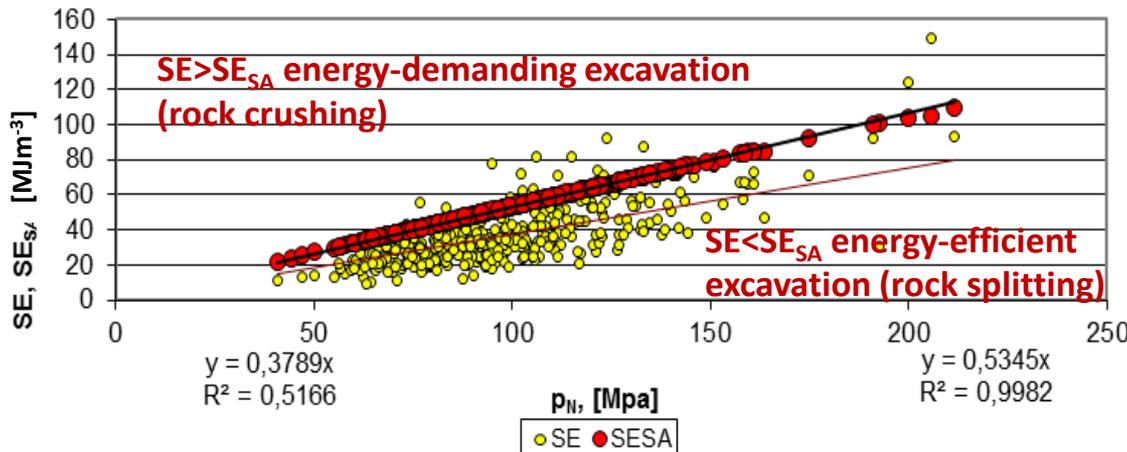
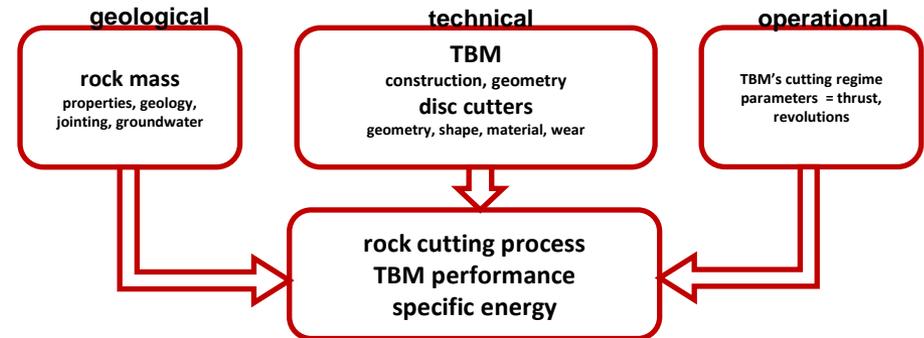


Research activities

Rock Cutting Processes in Tunnelling

- ✓ synthesis of geological and TBM operation regime parameters
- ✓ mathematical model of rock cutting process – interaction of disc and rock
- ✓ method for fast visualization of TBM efficiency based on specific energy

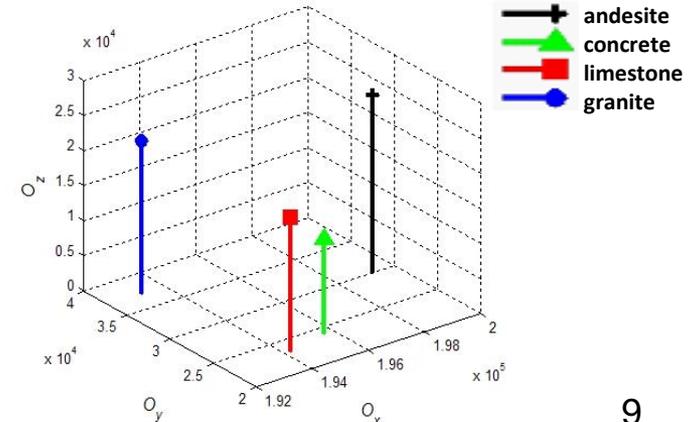
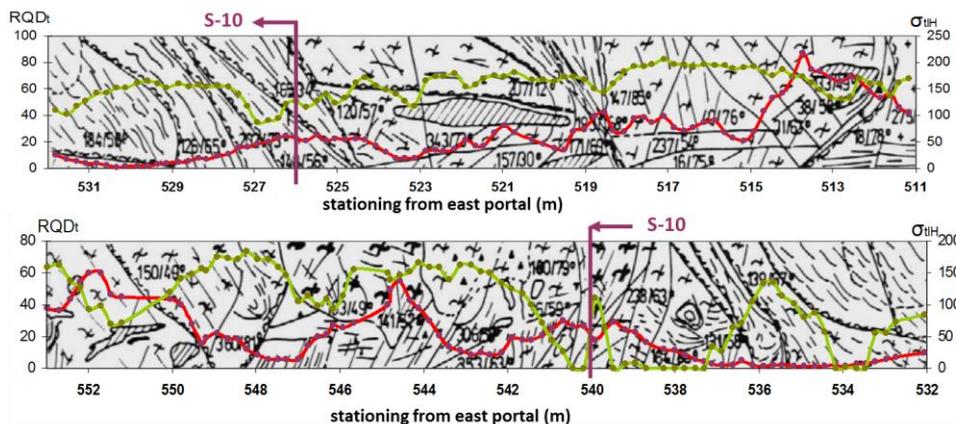
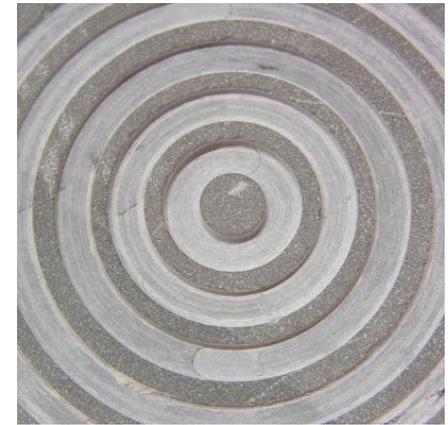
Factors affecting the TBM performance



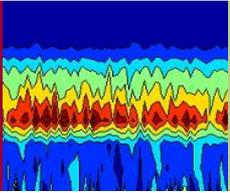
Research activities

Rock Drillability Assessment

- ✓ modelling and prediction of rock drillability upon input parameters of drilling process and indirect methods
- ✓ rock identification by vibrations accompanying drilling process
- ✓ study of relations between rock abrasiveness and drill bit wear
- ✓ geometrical interpretation of non-stationary character of tunnel excavation process using Hilbert's spaces
- ✓ skills in analysis of large datasets by statistics, artificial intelligence, data mining techniques



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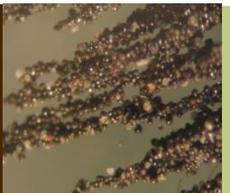
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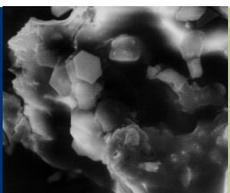
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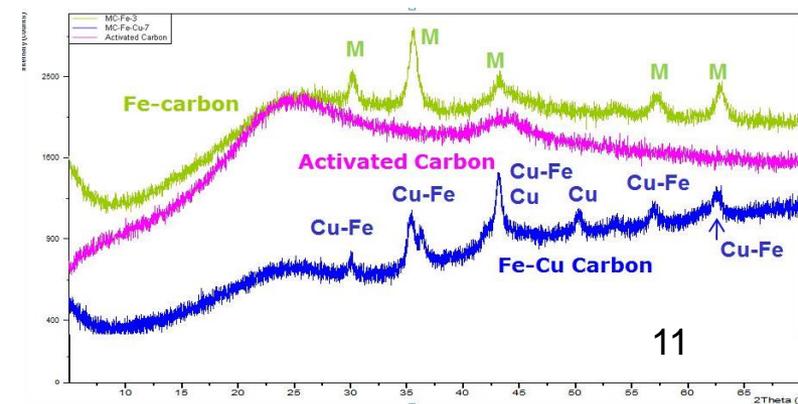
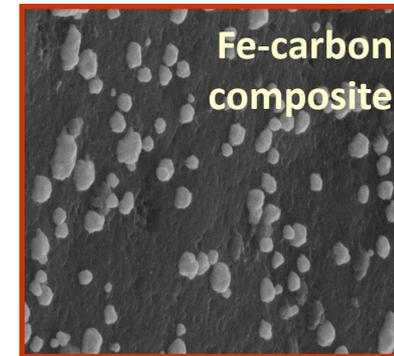
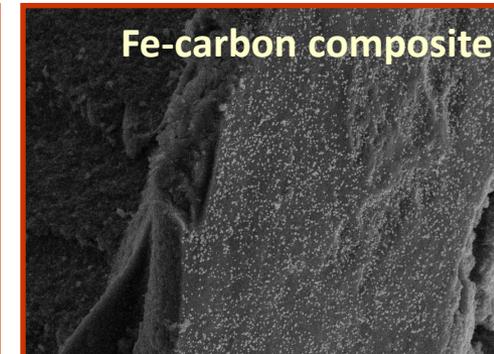
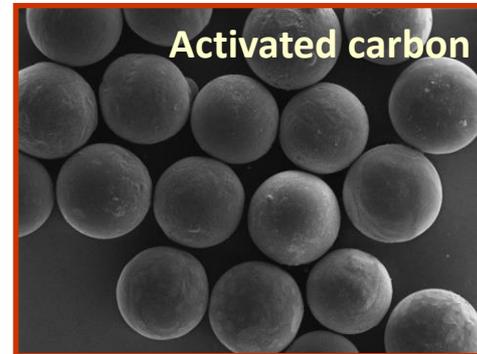
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Research activities

Removal of Toxic Substances from Waters and Soils

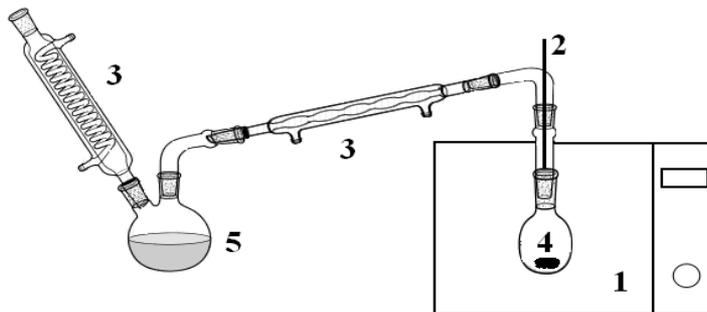
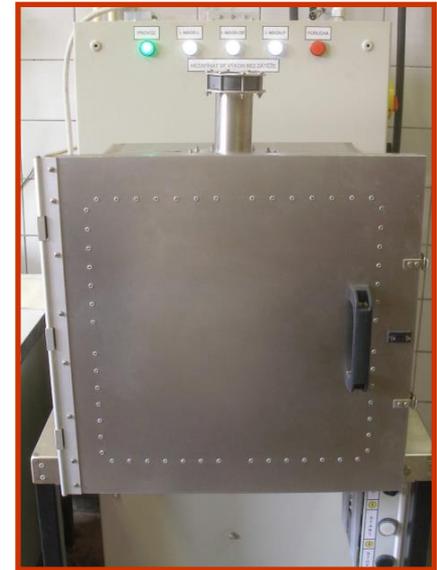
- ✓ preparation of sorbents based on iron oxides, zeolites and activated carbons
- ✓ embedding of engineered nanoparticles into the activated carbon/zeolite structure for safe use in the environment
- ✓ material study – chemical composition, mineralogical composition, magnetic properties, surface studies and pore structure studies
- ✓ modelling of water treatment processes
- ✓ utilisation of organic waste (biomass) for activated carbon development
- ✓ removal of xenobiotics (pesticides, organic dyes) by electrochemical oxidation
- ✓ **research group coordinating FP7-WaSClean project**



Research activities

Application of Microwave Field in Processing of Minerals and Biomass

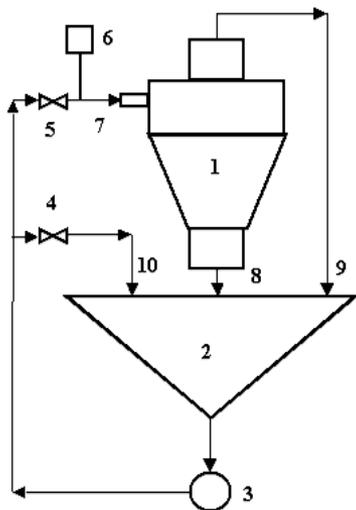
- ✓ study of dielectric properties of materials,
- ✓ microwave leaching of ores, by-products and wastes
- ✓ microwave modification of magnetic properties of Fe-materials
- ✓ microwave extraction of organic species from coal
- ✓ microwave vitrification of wastes from water treatment processes (metal loaded sorbents)
- ✓ toxicity, chemical and mechanical stability tests
- ✓ modelling of microwave heating of polycomponent materials



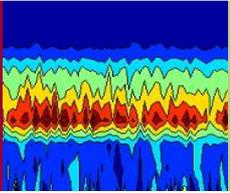
Research activities

Mineral Processing

- ✓ study of industrial minerals and their byproducts properties,
- ✓ pretreatment and washing of coal and fly ash in hydrocyclones
- ✓ upgrading of Slovak industrial minerals using gravity concentration, hydrocycloning, electrostatic and magnetic separation
- ✓ influence of mineral liberation on separation process efficiency
- ✓ S/L separation using magnetic field
- ✓ optimization of separation parameters



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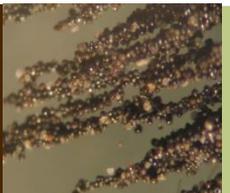
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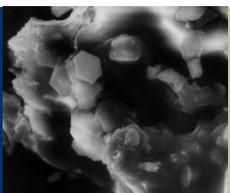
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Research activities

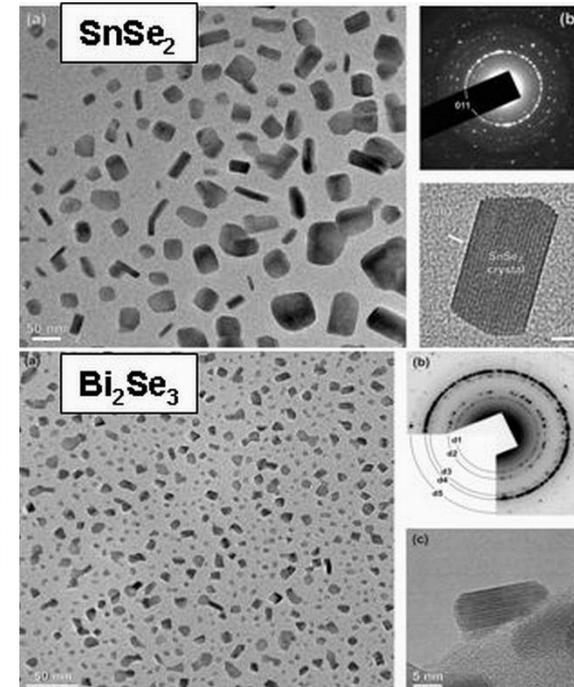
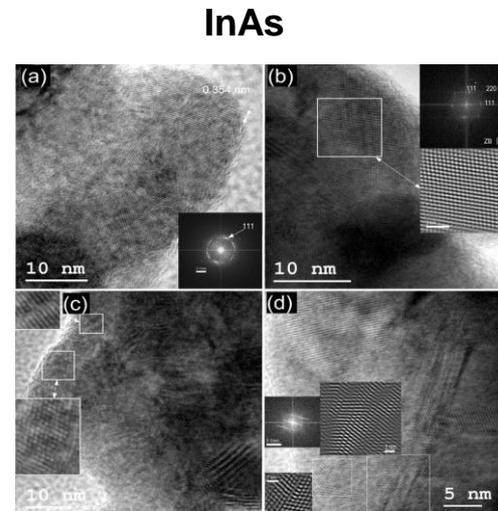
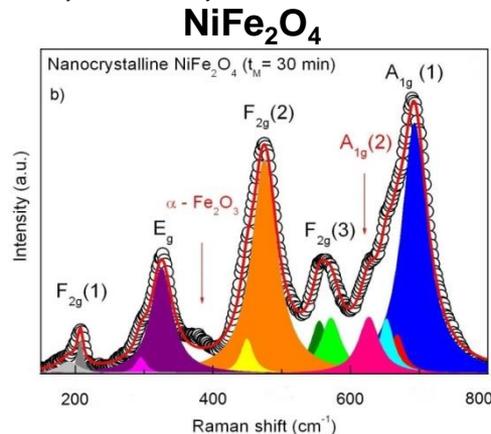
Synthesis of Nanomaterials

- ✓ **Oxides - spinels** (Zn_2SnO_4 , ZnAl_2O_4 , ZnGa_2O_4 , MgFe_2O_4 , NiFe_2O_4), **olivines** (Fe_2SiO_4 , Mg_2SiO_4), **perovskites** (BaLiFe_3 , BiFeO_3 , BaTiO_3), **mullites** ($\text{Bi}_2(\text{Ga}_x\text{Al}_{1-x})_4\text{O}_9$), **orthosilicates** ($\text{Li}_2\text{FeSiO}_4$)
- ✓ **Sulphides** ($\text{Cd}_x\text{Zn}_{1-x}\text{S}$, Sb_2S_3 , Bi_2S_3 , PbS , CdS , ZnS , CdS@ZnS , CuS , CuInS_2 , As_4S_4 ,)
- ✓ **Selenides** (BiSe , BiSe_3 , ZnSe , SnSe , SnSe_2 , PbSe , CuInSe_2 ,)
- ✓ **Arsenides** (InAs)
- ✓ **Silver NPs**

Potential applications:

✓ **Electronic industry** – semiconductors, photovoltaic cells, batteries, fuel cells based on sulfides, oxides, silicates

✓ **Medicine**

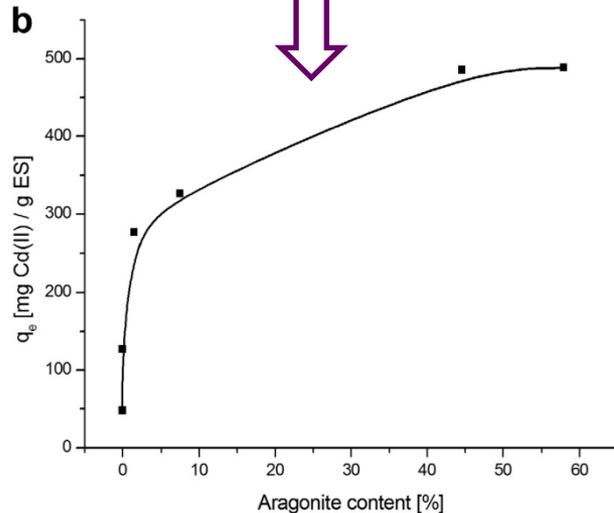


Research activities

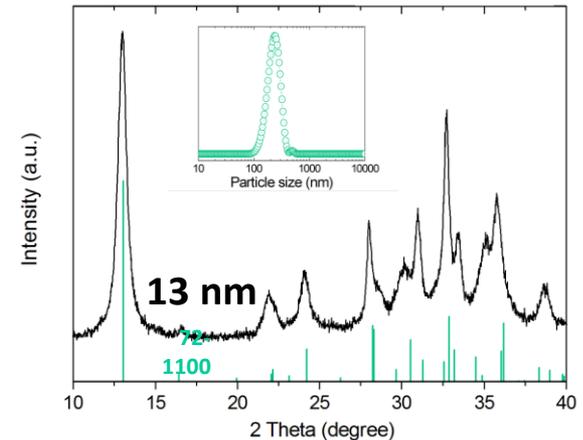
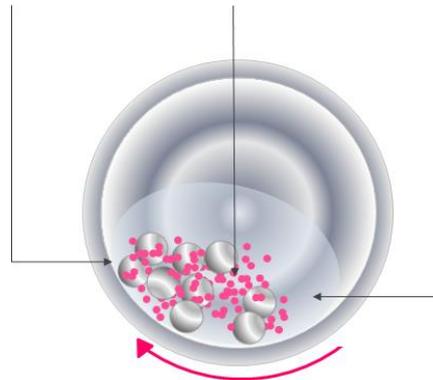
Activation of Materials for Environmental Applications

- ✓ Sorption of arsenic on magnetite (Fe_3O_4)
- ✓ Sorption of cadmium on eggshell (CaCO_3)
- ✓ CO_2 storage ($(\text{Mg,Fe})_2\text{SiO}_4$, ZnO , vermiculites)

Eggshell CaCO_3



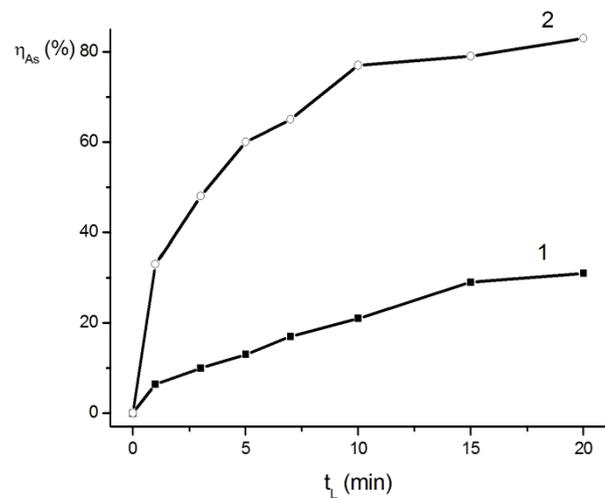
Mechanochemical carbonation – synthesis of carbonates



Research activities

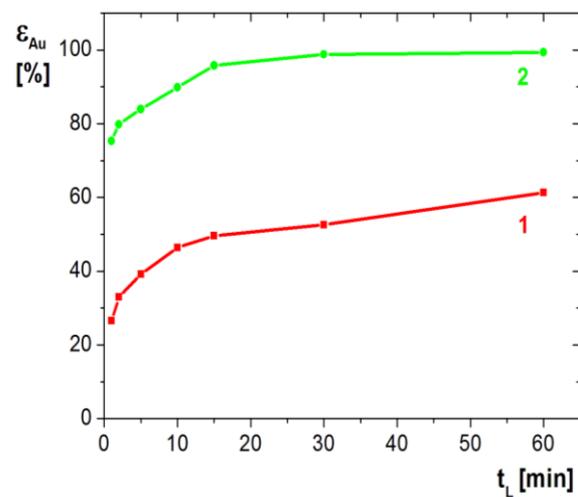
Hydrometallurgy

- ✓ Leaching of arsenic and antimony
- ✓ Leaching of gold

Leaching of arsenic from enargite (Cu_3AsS_4)

1 – non-activated sample
2 – activated sample

Leaching of gold from Golden ore (Biely vrch, Slovakia)



1 – non-activated sample
2 – activated sample



ARRA – Slovak Academic Rating and Ranking Agency

2013 – Department of Mechanochemistry – among 22 top team at SAS

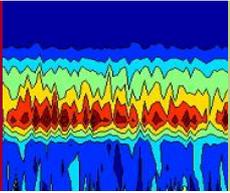


P. Baláž and V. Šepelák – top world mechanochemistry leaders

V. Šepelák – since 2014 – President of International Mechanochemistry Association

V. Šepelák – 2013 – ICDD Award for 10 patterns published in Powder Diffraction File International Centre for Diffraction Data (ICDD)

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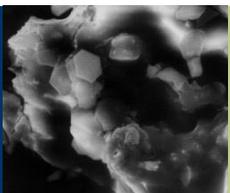
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Research activities

Geochemistry and Geomicrobiology

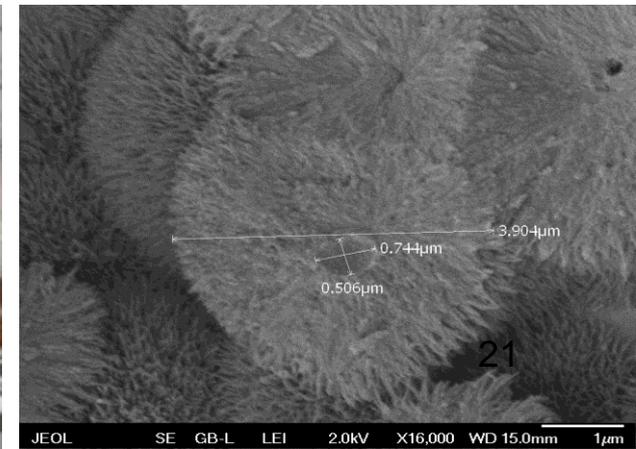
- ✓ bacterial action in the weathering processes and mineral transformation
- ✓ biogeochemical cycles of elements (C, Fe, S, N)
- ✓ acid mine/rock drainage (AMD) genesis, monitoring, remediation
- ✓ paragenetic sequence of mineral forms appearing in sulfide deposits
- ✓ bacterial metal mobilization and precipitation in the environment



Research activities

Applied and Environmental Microbiology

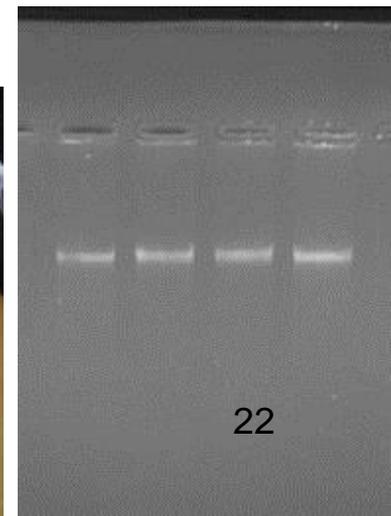
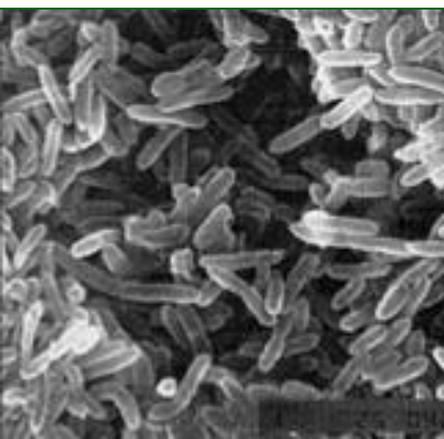
- ✓ oxidative and reductive bioleaching of metals from ores, soils and sediments
- ✓ iron-reducing bacteria, dissolution of iron(III)-oxides, deferrization of clay minerals and quartz sands
- ✓ preparation of nano-sized biogenic minerals for wastewater remediation
- ✓ biodegradation of organic pollutants



Research activities

Biodiversity Assessment

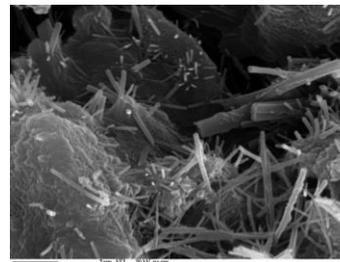
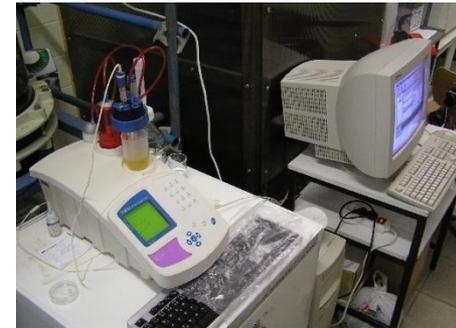
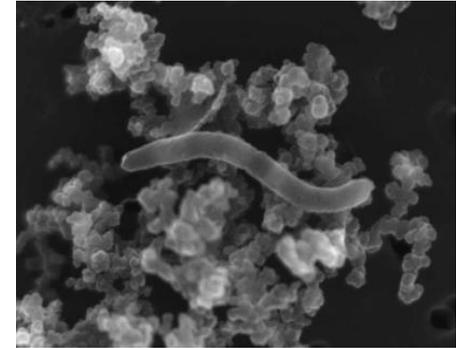
- ✓ evaluation of biodiversity in various environmental matrices
- ✓ isolation, identification and cultivation of bacterial strains
- ✓ DNA extraction, purification and amplification
- ✓ phylogenetic affiliation of the isolates based on DNA sequences coding for 16S rRNA



Research activities

Treatment of Acid Mine Drainage

- ✓ isolation and cultivation of sulfate-reducing bacteria (SRB)
- ✓ selective recovery of metals from AMD by selective sequential precipitation (SSP) using biogenic H_2S
- ✓ removal of sulfates from AMD
- ✓ sorbent preparation based on Fe-sulfides by SRB cultivation
- ✓ application of biogenic sorbent for heavy metal removal from wastewaters
- ✓ macroinvertebrates structure detection in AMD polluted streams
- ✓ biodeterioration of concrete



Research activities

Biodegradation of Organic Pollutants in Soil

oil hydrocarbons, PAHs, chlorinated pesticides



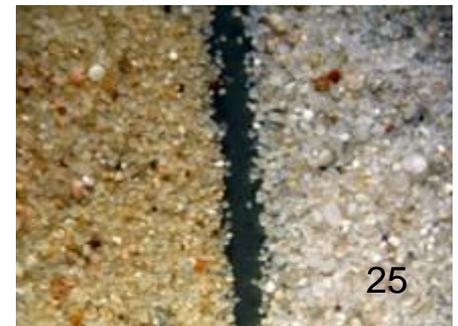
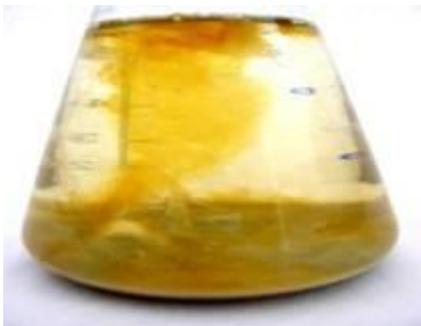
Gas analyzers for monitoring of O_2 , CO_2 and CH_4 in soil gas during the in-situ remediation



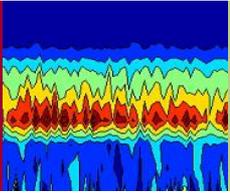
Research activities

Bacterial Deferrization of Clay Minerals and Silica Sands

- ✓ application of indigenous heterotrophic bacteria in bioleaching of non-metallic minerals (quartz sands, feldspars, kaolin)
- ✓ development of new technology for the purification of quartz sand
- ✓ quality improvement of non-metallic minerals
- ✓ research resulted in **submission of patent application in August 2016**



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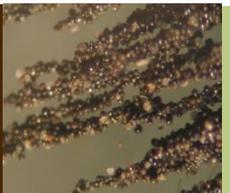
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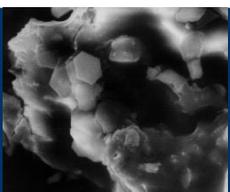
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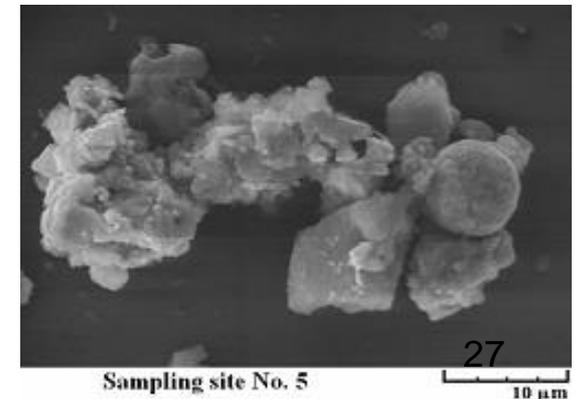
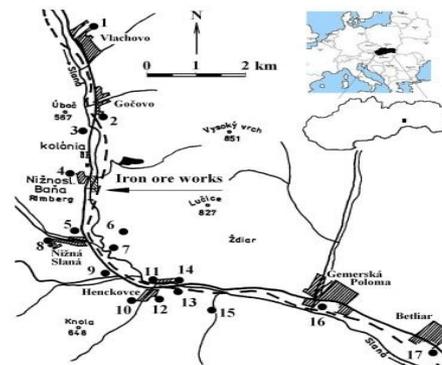
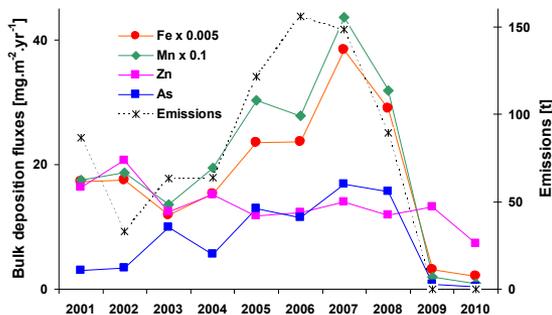
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Research activities

Study of Atmospheric Deposition and Solid Particles

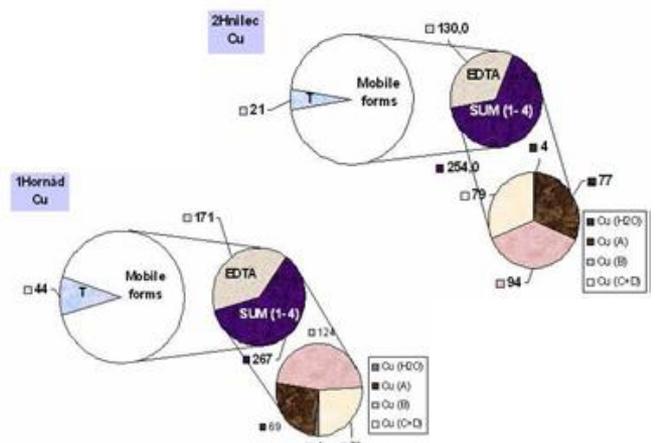
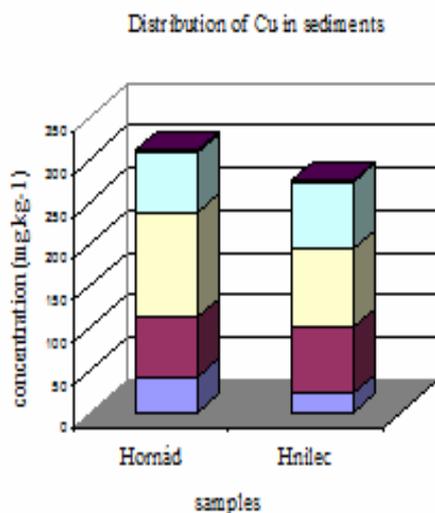
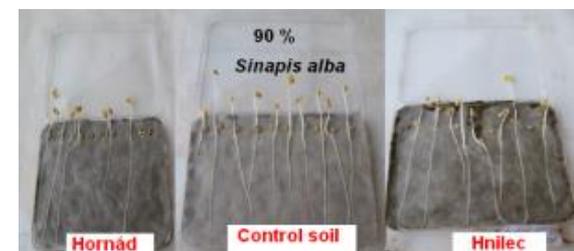
- ✓ research in the field atmospheric deposition of particulate matter is **the only one in Slovakia** and provides irreplaceable informations for assessing and research of air quality and thus the other components of the environment also in the international scale
- ✓ analysis of chemical composition of atmospheric pollution and gravimetrical analysis
- ✓ mineralogical, morphological, dispersion, size characterization of solid particles
- ✓ identification of deposition fluxes of selected pollutants
- ✓ identification and quantification of contributions of emissions on sources on environmental load



Research activities

Study of Bottom Sediments of Rivers and Water Dams in Industrial Areas

- ✓ assessment of potential contamination of soils, bottom and anthropogenic sediments by combination of spectroscopic methods (XRPD, FTIR, XRF, AAS) and thermal methods (TG/DTG, DTA) coupled with MS
- ✓ study of contamination of soils and sediments by ecotoxicological tests (phytotoxicity tests)



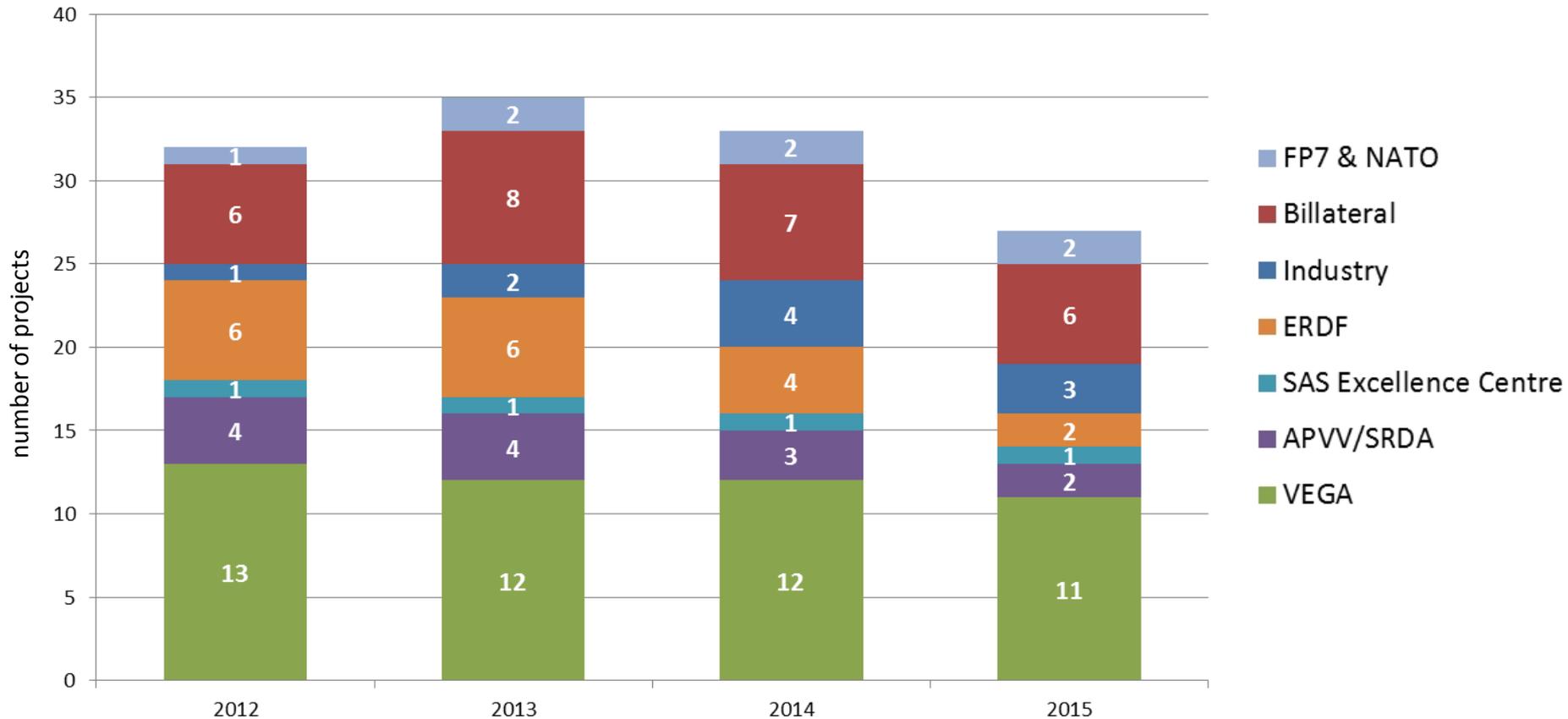
Central laboratory

- support, consulting and analytical services for research projects and commercial contracts,
- chemical analysis of minerals, sediments, soils, solid wastes, waste waters, aerosols, raw materials, etc.
- volumetric and gravimetric analysis,
- elemental analysis, analysis of aqueous solutions (waste waters, drinking waters, acid mine drainage, ground waters, surface waters, etc).

Service department - workshop

- maintenance and repair of general laboratory equipment,
- production and maintenance of small experimental equipment such as lab reactors, adsorption columns, rotary shakers, sieving shakers, sample holders, sample collectors, magnetic separators, electrolytical cells, tools for hydrocyclone, flow-through systems and other tailor-made devices designed in collaboration of researchers.

Structure of research projects

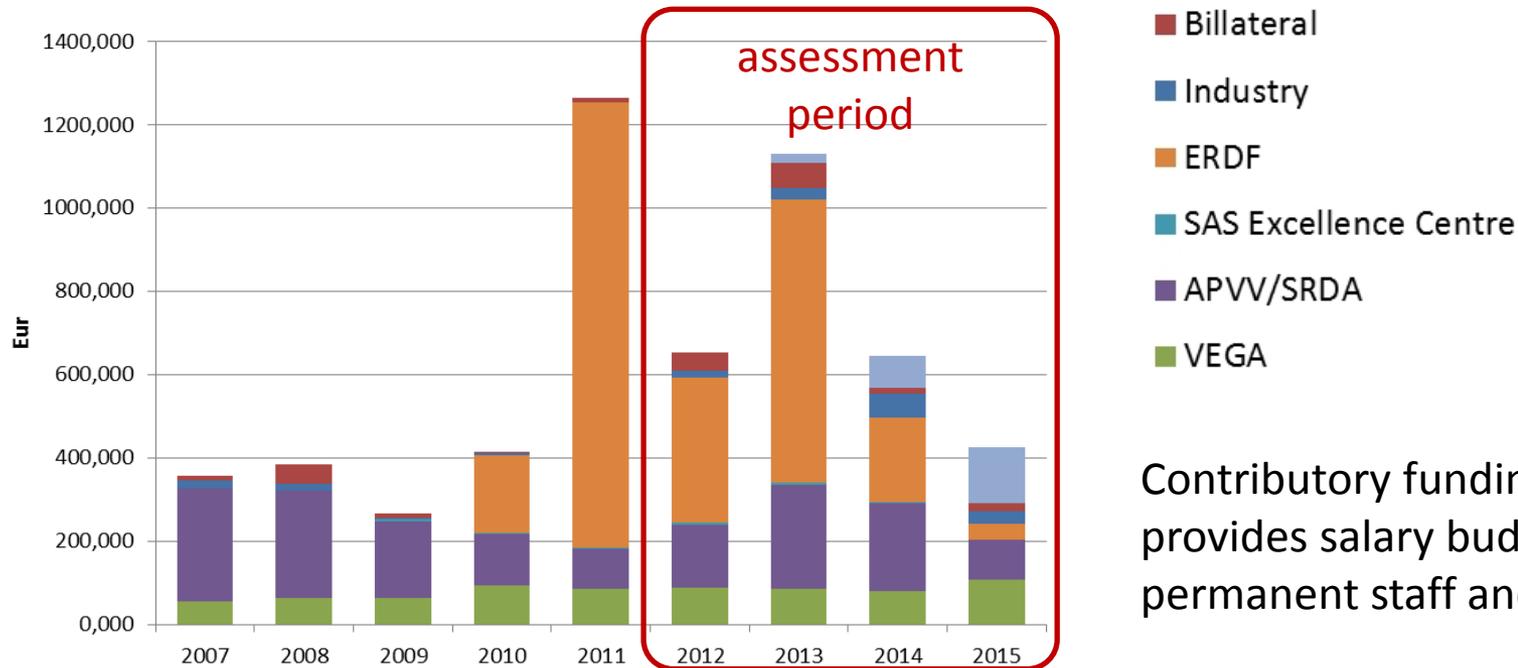


68 submitted proposals - 23 funded projects

45 passed threshold but not funded: 11 FP7/H2020/NATO, 2 COST, 2 ERDF, 24 APVV, 6 others

Success rate: 34 %

Funding of research projects



ERDF projects – development of new infrastructure

7 projects, over 3 million Euros

Slovak R&D Agency (APVV/SRDA)

5 projects – 750,000 EUR

VEGA - Slovak Grant Agency of Ministry of Education, Science and Sport

24 projects – 360,000 EUR

Contributory funding - SAS provides salary budget for permanent staff and PhD

17% from SAS as overhead budget, 83% from projects (competition)

The amount of funding obtained from international projects increased by 93%

International research projects

EU Framework Programme 7 – Industry Academia Partnership & Pathways

WaSClean - Water and Soil Clean-up from Mixed Contaminants

- project coordinator: Miroslava Václavíková, (2013-2017)
- transfer of knowledge between 4 academic and 4 SME partners (Slovakia, United Kingdom, Greece, Kazakhstan)
- training of Marie Curie Fellows via complementary skills
- 18 secondments from IGT, 6 to IGT

NATO Science for Peace & Security

Technical Advances to Detect and Remove Contaminants from Water for Safety and Security (2012-2016)

IGT SAS

- **significant international and national reputation** in all its research activities
- scientific group with a **strong interdisciplinary background**
- increased number of **invitations and participations** in international (FP7, H2020, NATO, COST) and national (ERDF, SRDA/APVV) research projects consortia
- **coordination** of major international (FP7) and national research projects
- several national and international **awards**
- regular requests for **reviews** on international and national project proposals, expert reports from regional authorities, reviews of scientific papers
- regular requests from **industry** to provide testing, measurements, assessment reports, etc. by companies active in civil engineering, metallurgy, chemistry, environment, etc.
- researchers act as members of **expert bodies** of national authorities

Conferences organized by IGT SAS

16 international regular conferences

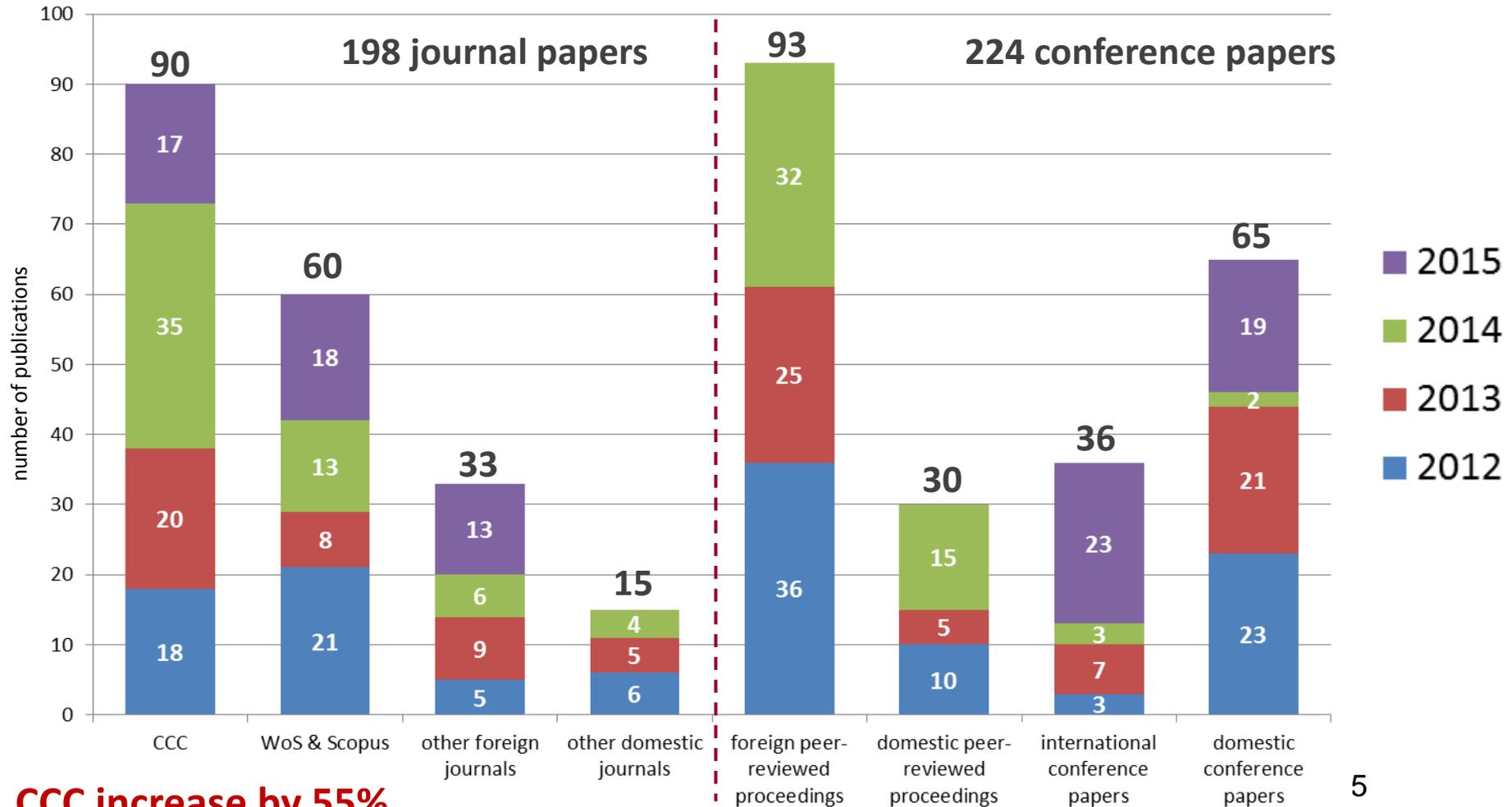
- Waste Recycling 2012, 2013, 2014, 2015
- Biotechnology & Metals 2014
- WaSClean Workshop 2014, 2015
- Preparation of Ceramic Materials 2013, 2015
- Structure and Properties of Nonequilibrium and Nanocrystalline Materials 2013, 2014
- The New Mineral Policy Conference - Progressive Technologies in Mining, Geology and Environment 2013, 2014, 2015
- Geotechnics 2012, 2014

Regular national conference series

- Scientific Symposium on Situation in Ecologically Loaded Regions of Slovakia and Central Europe 2012, 2013, 2014, 2015

Publications

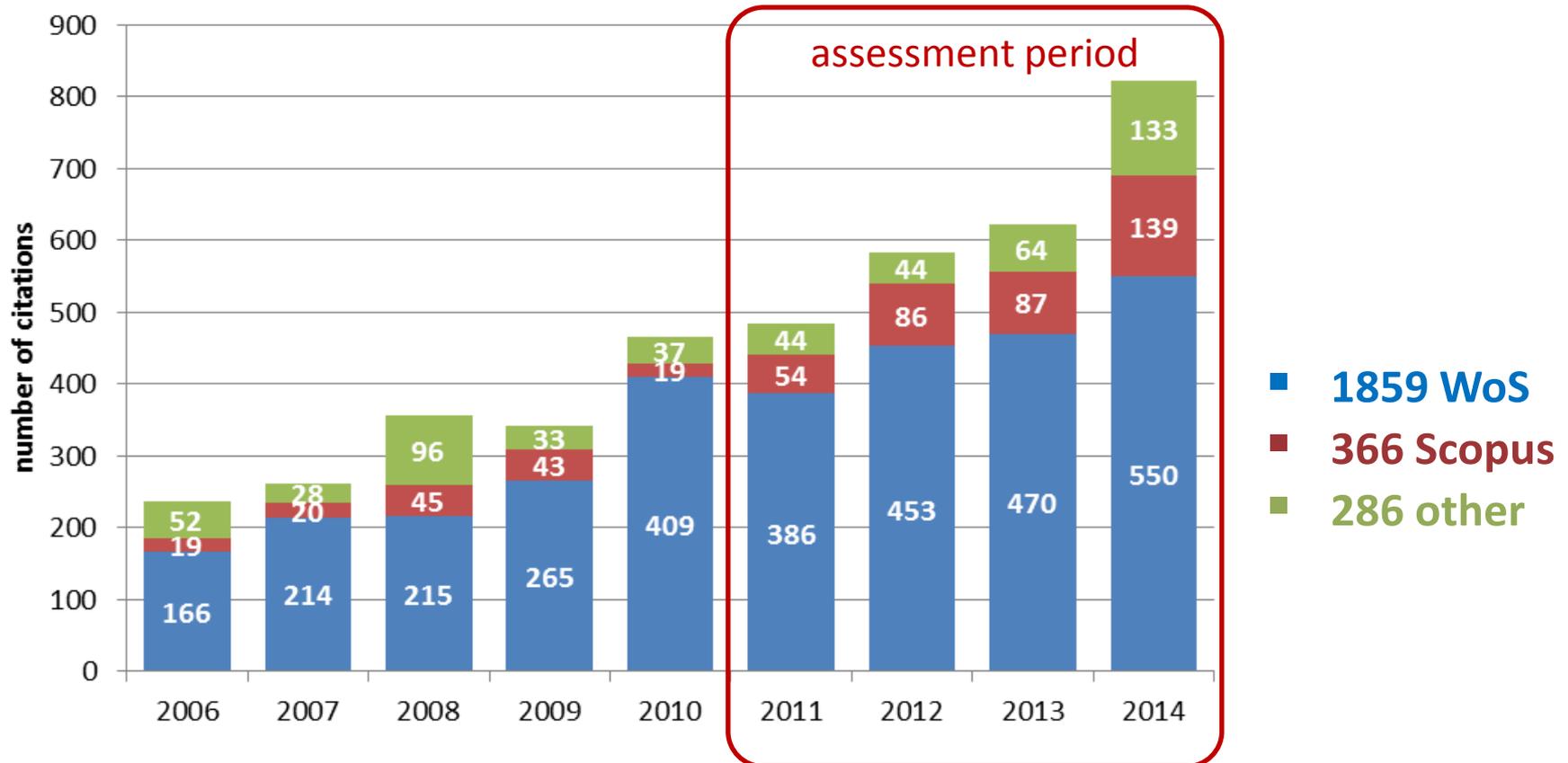
4 monographs, 2 chapters in monographs abroad



CCC increase by 55%

major research staff efforts in 2012-2015 given to implementation of 7 ERDF projects

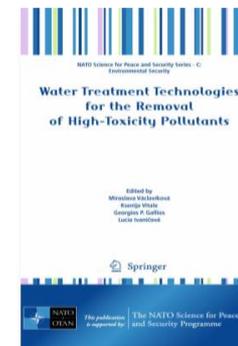
Citations



number of WoS citations **increased by 70%**, Scopus citations by **103%** compared to previous assessment period

Other responses to publications

- Responses to the book “Water Treatment Technologies for the Removal of High-Toxicity Pollutants” edited by M. Václavíková, G. Gallios, K. Vitale and L. Ivaničová, Springer, 2010. Among **top 25% most downloaded eBooks in Springers eBook Collection in 2014 and 2015**



Year	Chapter Downloads
2015	9,984
2014	12,226
2013	8,112
2012	1,407
2011	2,491
2010	2,144
2009	229

- Thomson-Reuters assigned the paper “Hallmarks of Mechanochemistry: from Nanoparticles to Technology”, Chem Soc Rev 42(18), 2013 in the **top 1% cited publications in Chemistry** in May/June 2016
- **P. Baláž (2012)** – Award of Presidium of SAS - Price for book “Mechanochemistry in Nanoscience and Minerals Engineering”, Springer, 2008.
- **P. Baláž, M. Baláž, E. Turianicová (2015)** – Award of Slovak Literature Fund for book “Material Chemistry”, VEDA, 2014 in category Natural and Technical Sciences.
- **P. Baláž (2012)** – Award of Slovak Literature Fund for excellent scientific response to book „Extractive Metallurgy of Activated Minerals“, Elsevier, 2000, in category Technical Science and Geoscience.

Indirect responses

Indirect positive responses to the research activities of IGT - **substantial positive recognition** by the following:

- increased number of **invitations** in international (FP7, H2020, NATO, COST) and national (ERDF, SRDA/APVV) research projects consortia,
- 25 **invited lectures** to international conferences/scientific events during reported period and 19 invited presentations for international scientific institutions,
- regular requests for **reviews**: 252 elaborated reviews of scientific papers, 7 reviews of monographs, 57 reviews of international and national project, of expert studies and project proposals requested by editorial boards of journals and research funding agencies
- **awards** granted to IGT researchers

Awards

V. Šepelák (2013) – International Centre for Diffraction Data (ICDD) Recognition Award for contribution of 10 published patterns to the Powder Diffraction File.

P. Baláž (2013) – Top team at SAS awarded by Slovak Academic Rating and Ranking Agency ARRA.

Young Researchers Awards by Ministry of Edu. & SAS

M. Fabián (2012) – Young Researcher's Award by Slovak Ministry of Education, Science, Research and Sports in category Science and Technology for Development of Mechanochemistry in Synthesis of Metastable Nanocrystalline Oxides.

Z. Danková (2013) – Commemorative Letter of the Minister of Education, Science, Research and Sports awarded for young researchers under 35 years for Structure properties of Composite Adsorbent Materials based on Bentonite and Iron Oxides for Environmental Applications.

Z. Bujňáková (2015) – 3rd place in Young Researchers Contest awarded by SAS for Arsenic Sulfide Nanosuspensions, Their Properties and Anti-Cancer Effects.

PhD Study

PhD in accredited study programme **Metallurgy**

- 22 potential supervisors – limited to 2 new students per year
- **18** PhD students in assessment period (6 defended, 9 running)
- **training** in laboratory techniques with free access to the equipment
- attending of specific **courses** at university
- **annual seminars** in English improving presentation and language skills
- participation on project applications – **individual fellowships**
- involvement in **project implementation** and **publication**
- active participation on **conferences** & organization of conferences
- **popularization** activities
- exchange visits, **secondments**

Post Docs

Supporting Fund of Stefan Schwarz – 3 successful applications

1. Ing. Zuzana Danková, PhD. 01.01.2011 – 31.12.2015
2. RNDr. Martin Fabián, PhD. 01.06.2012 – 17.02.2016
3. RNDr. Matej Baláž, PhD. 01.01.2016 – 31.12.2019 (submitted in 2015)

SASPRO-COFUND fellowship

– two applications (2015), one successful (from 03/2016)

ERDF funding – 8 postdoc positions

APVV/SRDA funding – 5 postdoc positions

Position of IGT SAS

- ✓ As a member of Slovak Mining Society and Slovak Mining Chamber IGT actively participates in panel discussions on **New Mineral Policy of Slovak Republic** focused on **critical minerals, base and precious metals and industrial minerals** for self-sufficiency of EU in raw materials.
- ✓ IGT takes part in the **projects related to the recovery of the environment** and development of new materials and technologies.
- ✓ All projects correspond to the **priority areas** of national RIS3SK strategy, EU H2020 and sustainable development strategy.
- ✓ IGT SAS has **unique position for transfer of knowledge** from academia to industry in the field of mining, mineral processing and environmental remediation.
- ✓ **Two patent applications are being prepared based on previous applied research projects with industrial partners**

Applied research projects as responses to the quality of research

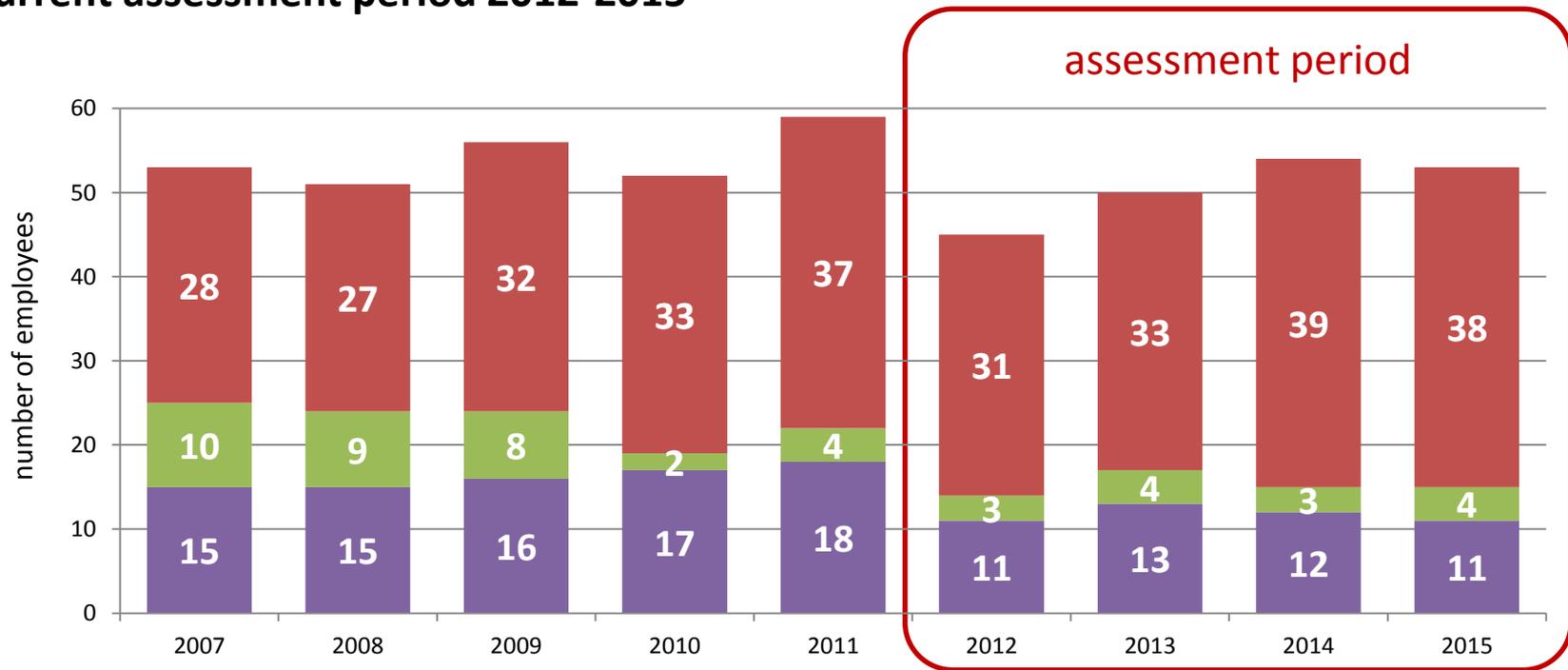
- **Liberalization of Ag/Au Particles from Silicate Matrix by Bioleaching** (2012-2013),
Contract research with Newmont Technologies Limited Denver, USA
- **Hydrometallurgical Technology of Antimony Recovery from Antimonite Concentrates** (2013-2014),
Contract research with Nihon Seiko Co. Limited, Tokyo, Japan
- **Mechanochemical Technology for Preparation of Nanocrystalline Material** (2014-2015),
Contract research with Nihon Seiko Co. Limited, Tokyo, Japan – **preparation of patent application**
- **Development of In-situ Bioleaching Method to Clean Quartz Sands and Application through Testing Prototype Pilot Plant** (2014-2016)
Contract research project: Cristalerias Chile - **submitted patent application**
- **Biocorrosion of Cement Composites** (2014-2015)
Contract research with cement company Považské cementárne a.s., Ladce, Slovakia

Expert reports

- 27 expert reports on technological rock properties, chemical characterization and analyses of materials, micro(geo)biological analyses, bioremediation assessment

Structure of employees

Current assessment period 2012-2015



- Researchers with PhD
- Researchers with univ degree
- Technical/administrative staff

Stable trend in the qualification growth of research staff

Average age 43 years – one of the ‘youngest’ SAS institutes

New management policy

- annual evaluation of scientific outputs of researchers
- supporting the international collaboration in FP7/H2020, NATO, COST, APVV and other proposals
- supporting the collaboration with industry and transfer of knowledge
- organizing the annual seminar of PhD students in English to improve the communication and presentation skills of researchers
- supporting international mobility
- motivating young researchers to apply for international individual fellowships

The activity of IGT raised significantly in most indicators.

- Number of CCC journal papers increased by 55%.
- Number of citations in WoS by 70%, in Scopus by 103%.
- The amount of funding obtained from international scientific projects increased by 93%.

Future development

Keep the growth

achievable by implementation of specified priority areas of national research strategy RIS3SK in new **upcoming ERDF projects**

- **Material research and nanotechnologies**
- **Biotechnologies and biomedicine**
- Agriculture and **environment**, including **environment-friendly modern chemical technologies**
- **Sustainable energy**

and in accordance with **H2020** and new policy of EU Strategy on the Sustainable Use of Natural Resources focused on **Resource Efficiency and Raw Materials**

- Sustainable selective **low impact mining**
- New technologies for the enhanced **recovery of by-products**
- New sensitive **exploration** technologies

IGT SAS keynotes

✓ Publications

Hallmarks of Mechanochemistry: From Nanoparticles to Technology (P. Baláž et al., *Chemical Society Reviews*, 2013, 42, 7571, **IF 24.892**)

Mechanochemical reactions and syntheses of oxides (V. Šepelák et al., *Chemical Society Reviews*, 2013, 42, 7507, **IF 24.892**)

✓ Project

FP7-WaSClean – M. Václavíková, coordinator

✓ Applied research leading to patent application soon

Development of In-situ **Bioleaching** Method to Clean Quartz Sands and Application through **Testing Prototype Pilot Plant** – Cristallerias Inc., Chile - I. Štyriaková, coordinator

Mechanochemical Technology for Preparation of Nanocrystalline Material - Nihon Seiko Inc., Japan – P. Baláž, coordinator

✓ Award

Prof. V. Šepelák - ICDD Recognition Award – for contribution of **10 published patterns** to the Powder Diffraction File (2013)

pollutants well advanced industrial
 methods development cutting
 application representative parameters technology microbial optimization
 biogenic recovery nanoparticles pyrolysis
 techniques technological sulphate-oxidising activated
 environmental conventional
 raw etc interpretation physical other medical mining
 environment
 novel time POPs dyes
 life life drillability material
 clean-up drilling acoustic
 impact study sorption extraction chemical processing
 Earth data toxic protection microwave
 mechanics degradation process related wastes
 metals synthetic rock transformation
 leaching power soils separation bacteria
 materials applications composite
 vibration mechanochemical groundwaters monitoring



Institute of Geotechnics
Slovak Academy of Sciences



Thank you for your attention