



**Institute of Rock Structure and Mechanics
of the Czech Academy of Sciences**



ANNUAL REPORT 2019

Translation

Compiled: 30 April 2020

Discussed by the Supervisory Board on June 5, 2020

Approved by the Institution's Council on June 8, 2020

Prague, June 9, 2020

For informative purposes only. The legally binding text is the one in Czech

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I. Information on the composition of the statutory bodies of the Institute of Rock Structure and Mechanics of the Czech Academy of Sciences (IRSM) and the activities thereof

Composition of the Institute's statutory bodies

Managing Director: RNDr. Josef Stemberk, CSc.

Board of the Institute:

Chairperson: Ing. Martin Černý, PhD.

Vice-chairperson: Mgr. Martina Havelcová, PhD.

Internal members: Ing. Olga Bičáková, PhD.,
RNDr. Jiří Málek, PhD.,
RNDr. Josef Stemberk, CSc.
Ing. Tomáš Suchý, PhD.
RNDr. Petra Štěpančíková, PhD.

External members: Prof. RNDr. Pavel Coufal, PhD.
(Charles University, Faculty of Natural Sciences),
Prof. RNDr. Tomáš Fischer, PhD.
(Charles University, Faculty of Natural Sciences),
Ing. Pavel Kriegsman, (KM, s.r.o.),
RNDr. Bohuslav Růžek, CSc.
(Academy of Sciences, Geophysical Institute)

Secretary of the Board: Doc. RNDr. Pavel Straka, CSc., DrSc.

Supervisory Board:

Chairperson: Doc. RNDr. Pavel Krejčí, CSc.
(Academy of Sciences, Mathematical Institute)

Vice-chairperson: Mgr. Lucia Fojtíková, Ph.D.
(Academy of Sciences, IRSM)

Members: Ing. Jana Jeřábková
(Office of the Academy of Sciences, Economic
Department), to 3 July 2019;
Ing. Radek Sedláček, PhD., (Czech Technical University,
Faculty of Mechanical Engineering), from 3 July 2019
Doc. RNDr. Bohdan Kříbek, DrSc.
(Czech Geological Survey)
Prof. RNDr. Jakub Langhammer, PhD.
(Charles University, Faculty of Natural Sciences)

Secretary of the Board: RNDr. Filip Hartvich, PhD.

Activities of the Institute's statutory bodies

Managing Director:

- The managing director issued a total of 7 organisational communications during 2019. Meetings were held on a monthly basis between the Institute's management and heads of department.
- The newly-constructed conference centre was put into full operation and used for several professional events – an international summer school on active tectonics and geomorphology, lectures presented by foreign researchers, a seminar for young science and research workers, a presentation of the results of doctoral and post-doctoral students, popularisation events, training sessions and meetings.
- Contracts were concluded for three new Czech Grant Agency (GA CR) projects and for two projects commissioned by the Ministry of Education, Youth and Sports and the Ministry of Health.
- The publication activities of the Institute's researchers were assessed in the form of a competition, and the results subsequently published.
- The participation of 3 doctoral students, 5 post-doctoral students and 9 researchers at international conferences received financial support.
- A total of 6 construction projects were realised, of which 2 construction contracts will continue into 2020. In addition, 13 contracts for equipment were fulfilled, of which 3 were co-financed by the Academy of Sciences of the Czech Republic, laboratory furniture was purchased on the basis of a public tender process and the supplier of a new executive information system (EIS) was selected in a consortium with other Academy of Sciences institutes. The new system is due to be launched on 2 January 2021.
- A book entitled "Science below Rokoska Hill – History of the Institute of Rock Structure and Mechanics of the Czech Academy of Sciences (ASCR) and its predecessors", published in cooperation with the Masaryk Institute and the ASCR Archive on the 90th anniversary of the Institute and 90 years of research in the Rokoska area, was translated into English. The English version is intended for representation purposes.

Board of the Institute:

The Board of the Institute held four regularly-scheduled meetings during 2019 (24 April, 17 June, 9 October and 12 December).

- 24 April. Economic and personnel issues and the budget in 2019 were discussed, as were the establishment of international advisory boards, institute assessments for the period 2015 - 2019 and a proposal for the inclusion of post-doctoral students in the PPLZ (the support of promising personnel) programme under Academic Council Directive no. 7 of 12 February 2019. Two proposals were submitted for the awarding of the 2019 Otto Wichterle Prize, and the translation into English of the book "Věda pod Rokoskou" (Science below Rokoska Hill) on the history of the Institute was discussed.
- 17 June. The preliminary determination of the IRSM teams to be subjected to the assessment of their research and professional activities for the period 2015 – 2019; the classification into fields thereof according to the OECD sectoral breakdown and

code list will subsequently be provided to the ASCR. The Directive on the Method for Managing the Results of Scientific and Research Activities of the IRSM was discussed, and the managing director of the IRSM provided information on the preparation of the IRSM International Advisory Board.

A proposal for an IRSM project was submitted to the TACR Gama 2 programme concerning the verification of the application potential of the research results of the IRSM (solution for 2020 - 2022), in connection with which a so-called commercialisation committee will be established to assess proposals for the application of the Institute's research results in practice.

- 9 October. The Principles for the Management of the Social Fund for 2019 document was discussed and appendix no. 1 was approved, the drawing of institutional overheads and charges, own resources and wage costs were discussed, and approval was granted for drawing on the reserve fund. As part of the assessment of the research conducted in the period 2014 - 2018 according to the M17+ methodology, selected results were submitted in due time to the Ministry of Education, Youth and Sports. A discussion took place on the staffing of the IRSM International Advisory Board; the Status and Rules of Procedure of the Board document will be prepared and submitted for approval via letter to the members of the Board of the Institute.

A seminar was held for young workers in the field of science on 1 October.

At a meeting held on 2 October, IRSM researchers elected Dr. Martina Havelcová as the IRSM representative on the ASCR Scientific Council.

- The management of the Social Fund will continue according to existing principles until the end of 2019; from 1 January 2020 the Fund will be managed according to a new, amended directive. The Report on the Management of the IRSM, 2019 and an outline of the budget for 2020 were discussed. The so-called Council for the Commercialisation of the Results of the IRSM was established to manage the project submitted by the Institute under the TACR Gama 2 programme.

Supervisory Board:

In accordance with the Rules of Procedure, the Supervisory Board met twice in 2019, and discussed a total of 5 issues via letter. The Board was provided with the financial results of the Institute, its 2018 Annual Report and the budget for 2019.

- The first meeting of the Board, held on 29 April 2019, included the verification and approval of the minutes of the 2/2018 meeting, a discussion on the disbursement of the IRSM budget in 2018 and the outlook for 2019, and a discussion on, and the noting of, the financial and auditor's reports. Further, the Board discussed and approved the Report on the Activities of the IRSM Supervisory Board for 2018 and the IRSM 2018 Annual Report. The activities and results of the IRSM were discussed and the Board was informed of organisational changes and scientific and management issues. A proposal for the assessment of the managing director of the IRSM was discussed and modifications proposed. Finally, the granting of the prior written consent of the Board concerning the conclusion of lease agreements between the IRSM and the ASCR Masaryk Institute and Archives, and between the IRSM and Mgr. Medvecká was discussed and approved.

- At its second meeting, which took place on 5 December 2019, the Board verified postal votes nos. 1/2019, 2/2019, 3/2019 and 4/2019 and verified and approved the minutes of meeting 1/2019. The Board further discussed the disbursement of the budget in 2019 and the outlook for 2020, and discussed the IRSM's 2019 activities and results as presented by the managing director. The Board also discussed and granted

its prior written consent for the conclusion of a lease agreement between the IRSM and the ASCR Masaryk Institute and Archives. Further, the Board gave its consent to the IRSM's intention to transfer funds from the Reserve Fund to a deposit account. Finally, the Board discussed the status of the tendering process for the new executive information system (EIS).

- During 2019, the Board discussed and approved 5 draft resolutions by letter with concern to:

- 1) the granting of prior written consent to a proposal for investment in the high-cost equipment of the ASCR (a microscope with accessories with a total estimated price of CZK 19.44 million, excluding VAT), accepted on 27 May 2019;
- 2) the approval of the proposed assessment of the managing director of the IRSM, in the form in which it was submitted (accepted on 27 May 2019);
- 3) prior written consent to the intention of the IRSM to announce a tendering process for the supplier of an economic information system according to the submitted documentation (accepted on 12 August 2019);
- 4) the appointment of ACONTIP, s.r.o., as the IRSM's financial auditor for 2019 (accepted on 12 August 2019);
- 5) the approval of the proposal of the IRSM managing director to transfer funds from the Reserve Fund to a deposit account according to the submitted offer (accepted on 7 January 2020).

II. Information on changes to the Institute's charter

No changes were made to the Institute's charter during the year.

III. Evaluation of the Institute's main activities

1. Results of the Institute's scientific activities

The scientific activities of the Institute were performed in the context of the Long-term Research Organisation Conceptual Development Project, no. RVO 67985891 and concerned:

- Geoscientific research:

Rock mass research focusing on the conditions for the creation of natural and induced geodynamic phenomena and activities underway in the upper layer of the earth's crust that threaten the stability of the earth's surface aimed at minimising the adverse impacts thereof; the monitoring and study of seismic wave propagation in various rock environments; the monitoring and analysis of slope movements in the Czech Republic, Slovakia, Peru and Svalbard; the monitoring and analysis of tectonic movements in Europe, the USA and Svalbard; the study of paleo-seismic activity along active faults in the Czech Republic and the USA, paleo-stress conditions in the Bohemian Massif and the seismic threat in the western Himalayas; the description of the development of the georelief in polar and alpine regions; the organic petrology and geochemistry of the oxide minerals of topaz granites.

- Materials research:

The study of raw materials and organic and inorganic materials focusing on the properties thereof and their application in the fields of medicine, glass production, ecology (sorption materials, waste treatment) and the renovation of buildings, as well

as the development of socially important technologies. The various research areas included: the preparation and description of the properties of collagen materials for use in medicine; the development of composite materials for high-temperature applications; the modelling of smelting processes and the development of new smelters; the vitrification and fixation of radioactive waste; the preparation of infrared translucent glass and the characterisation thereof; the preparation of new geopolymer composites and mixtures for the repair of concrete surfaces; the development of technologies for the heat treatment of biomass, sewage sludge and plastic waste mixtures. Recently, the large-scale study of energy storage was launched.

The Institute has achieved a number of significant results thanks to international cooperation and cooperation with universities, for example:

- 1) The paleo-seismic research of the Elsinore fault in southern California revealed the slip rate over the past 150 thousand years and the frequency of large earthquakes.

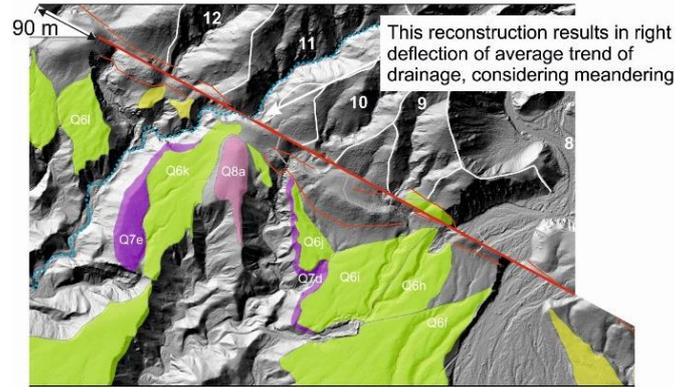
In order to determine the velocity of movement along the Elsinore fault, the most important western branch of the San Andreas Fault in Southern California, the study was carried out of alluvial cones at the foot of the Coyote Mountains that have been severed and shifted by this fault. The results of the research revealed a fault movement velocity of 2.4 ± 0.4 mm/year over the last 150 thousand years. In combination with the estimated magnitude of earthquakes from the shift following previous earthquakes, the large earthquake ($M_w \sim 6.8$) repetition period was estimated at one thousand years.

Publication:

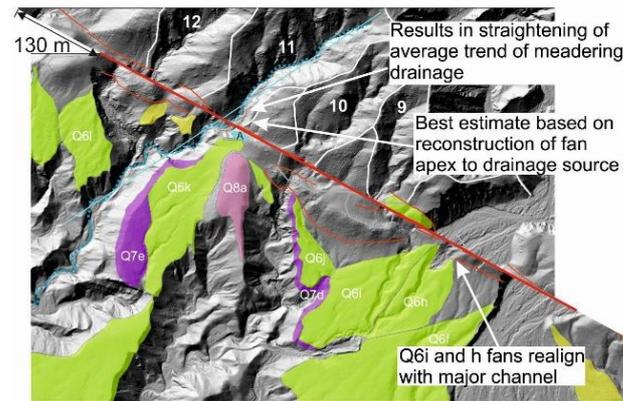
Rockwell T.K., Masana E., Sharp W.D., Štěpančíková P., Ferrater M., Mertz-Kraus R. (2019). Late Quaternary slip-rates for the southern Elsinore fault in the Coyote Mountains, southern California from the analysis of alluvial fan landforms, clast provenance, soils, and the U-series dating of paedogenic carbonate. *Geomorphology* 326, 68–89. doi.org/10.1016/j.geomorph.2018.02.024.

The result were achieved in collaboration with San Diego State University, the University of Barcelona, the Berkeley Geochronology Centre and the Institute for Geosciences at Johannes Gutenberg University, Mainz.

Minimum offset estimate - 90 meters



Best offset estimate - 130 meters



Maximum offset estimate - 160 meters

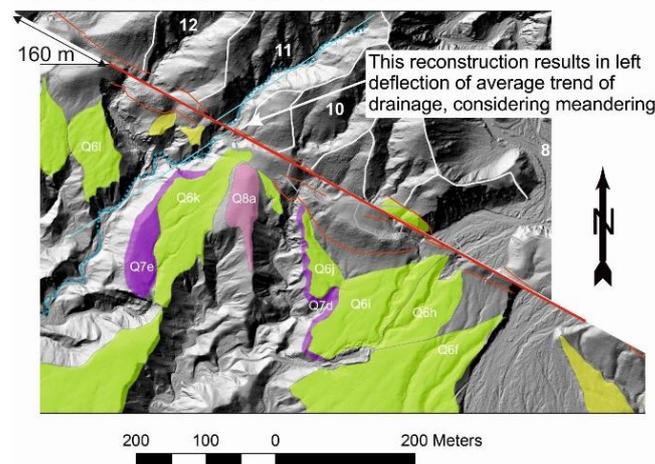


Illustration of the results from 1): Example of the reconstruction of the original site of an alluvial fan via the reverse shifting of the Elsinore fault. Reconstruction of the Q6jk alluvial fan in the Coyote Mountains associated with source valley 11 severed by the Elsinore fault. The best estimate of a displacement of 130 m is based on the reconstruction of the fan apex and the straightening of the average trend of the meander flow. The minimum estimate (90 m) leads to the significant right-hand deflection of the streams, while the maximum displacement (160 m) leads to the left-hand diversion of the streams.

2) Collagen-calcium phosphate nanofibrous layers for implant survival rate enhancement.

Collagen nanofibre layers with hydroxyapatite, saturated with the antibiotic vancomycin or its combination with gentamicin, offer a means of preventing infection during various types of operation such as joint replacement procedures. Such layers, developed in cooperation with a number of research institutions and Czech implant manufacturers, can be applied directly to the surface of joint replacements. Following the insertion of the implant, they act to both accelerate fusion with the bone and prevent infection; they also enhance the lifetime of the implant.

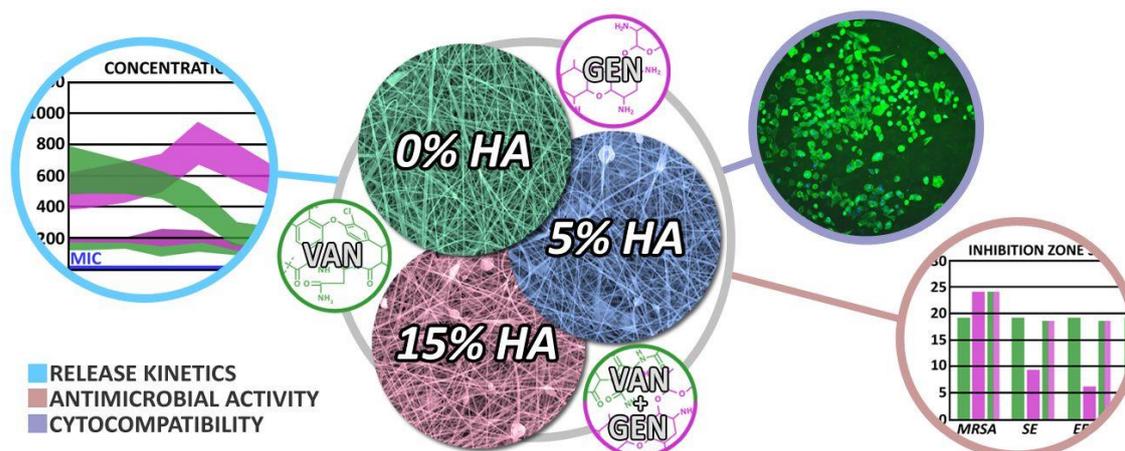


Illustration of the results from 2): Scheme of a collagen-calcium phosphate nanofibre layer for the enhancement of the lifetime of implants. Collagen nanofibre layers containing hydroxyapatite nanoparticles (HA, 0%, 5% or 15%) can be used as the surface layers of implants. Moreover, due to their containing various types of antibiotics such as vancomycin (VAN) or gentamicin (GEN) and their combinations, they can be used in certain operations to prevent the development of deep infections. The layers then act as local carriers of antibiotics, are antibiologically effective, do not exert systemic stress on the body, are not toxic to cells and accelerate the adhesion of the implant to the bone.

The results were achieved in cooperation with the Faculty of Mechanical Engineering of the Czech Technical University in Prague, the 1st Medical Faculty of Charles University, the Biomedical Centre of the Medical Faculty of Charles University in Pilsen and the Institute of Microbiology of the Medical Faculty of the Slovak Medical University in Bratislava.

Publication:

Suchý T., Šupová M., Sauerová P., Kalbáčová M.H., Klapková E., Pokorný M., Horný L., Závora J., Ballay R., Denk F., Sojka, M., Vištejnová L. (2019). Evaluation of collagen/hydroxyapatite electrospun layers loaded with vancomycin, gentamicin and their combination: Comparison of the release kinetics, antimicrobial activity and cytocompatibility. *European Journal of Pharmaceutics and Biopharmaceutics* 140, 50–59. doi: 10.1016/j.ejpb.2019.04.021

3) Cold-cap formation from a slurry feed during nuclear waste vitrification.

The time-temperature history of the input slurry associated with the vitrification of radioactive waste significantly affects kinetic processes such as reaction and

dissolution processes and the melting rate. The study addressed the formation of the cold crust and the interaction of an aqueous inlet slurry with the cold crust. The thermal conductivity of the crust was also determined. Samples were prepared via the controlled rapid evaporation of water from the slurry; they were then cooled and, in the second stage of the study, the slurry was poured onto the surface of the formed crust. The degree of penetration between the inlet slurry and the cold crust was then investigated by means of X-ray fluorescence. It was determined that the water-soluble components tend to concentrate at the bottom. Furthermore, the thermal conductivity of the crust was calculated from the measured temperature profile. The consequences of the formation of the crust in a real melting aggregate were then interpreted with respect to a mathematical model of crust formation.

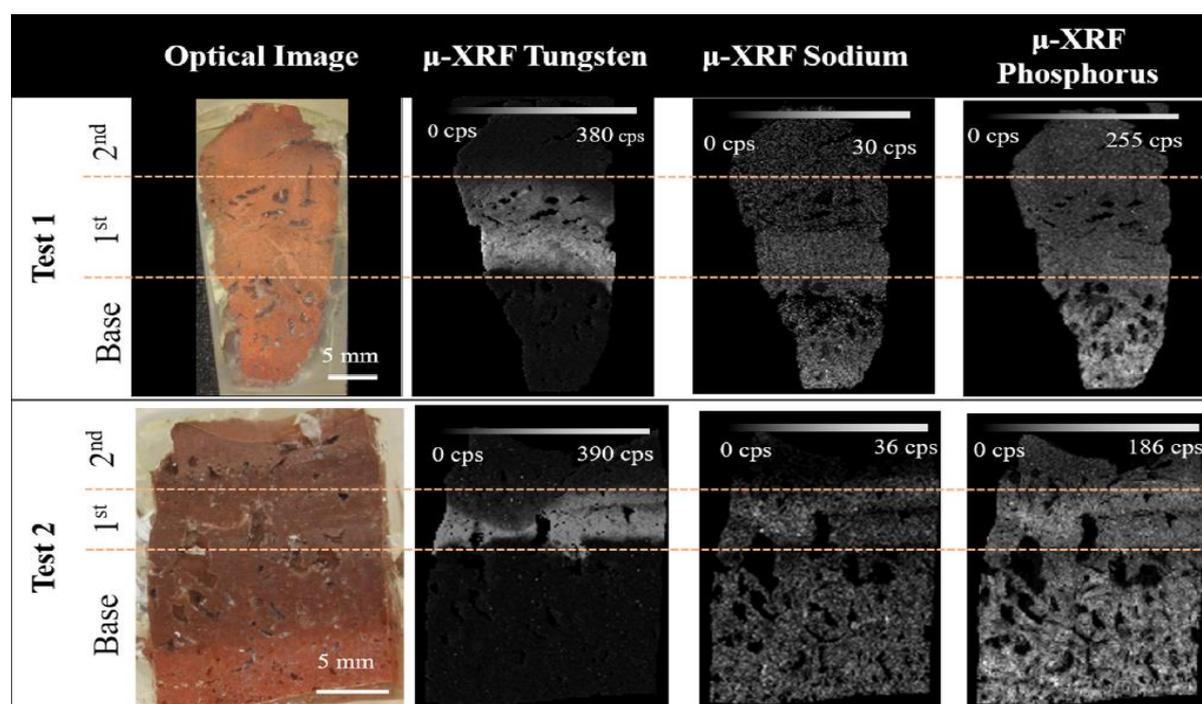


Illustration of the results from 3): The distribution of tungsten, sodium and phosphorus in the samples obtained via two testing campaigns, 1 and 2, and subsequently assessed via μ -X-ray fluorescence. The dashed lines indicate the boundaries between the basic phase and the first and second pourings of the slurry.

The results were achieved in cooperation with the University of Chemistry and Technology in Prague and Pacific Northwest National Laboratory, U.S. Department of Energy.

Publication:

Hujová M., Kloužek J., Cuthforth D.A., SeungMin L., Miller M.D., McCarthy B., Hrna P.R., Kruger A.A., Pokorný R. (2019). Cold-cap formation from a slurry feed during nuclear waste vitrification. *Ceramics International* 45 (5), 6405–6412.
doi.org/10.1016/j.ceramint.2018.12.127

2. Activities and selected results of the Institute's scientific departments

The Department of Engineering Geology focused on the analysis and interpretation of dangerous geodynamic phenomena associated with both exogenous (slope deformations and weathering) and endogenous processes (fracture movements). Particular attention was devoted to the development of reliable and accurate methods for the monitoring of slope and tectonic phenomena and the prediction of their occurrence and development.

Outputs:

1) A comprehensive global database of giant landslides on volcanic islands. The study compiled and summarised statistical data and other information on giant landslides on volcanic islands. The research revealed that landslides on volcanic islands - volcanic collapses - are among the most extensive on Earth and are comparable in size to extra-terrestrial landslides observed on Mars.

Publication:

Blahůt J., Balek J., Klimeš J., Rowberry M.D., Kusák M., Kalina J. (2019). A comprehensive global database of giant landslides on volcanic islands. *Landslides* 16, 2045–2052. doi.org/10.1007/s10346-019-01275-8

2) The current kinematic behaviour of active faults in the Eastern Alps. The study provided the first comprehensive insight into the kinematic behaviour of active faults in the Eastern Alps. Three-dimensional high-resolution measurements allowed for the observation of various types of aseismic movements along fractures. It was determined that periods of increased fracture activity frequently coincided with periods of increased local seismic activity; the contra-directional movement of fractures in many cases were found to precede significant local earthquakes, probably caused by the release of elastic stress in the subsoil.

Publication:

Baroň I., Plan L., Sokol L., Grasemann B., Melichar R., Mitrovic I., Stemberk J. (2019). Present-day kinematic behaviour of active faults in the Eastern Alps. *Tectonophysics* 752, 1–23. doi.org/10.1016/j.tecto.2018.12.024

Further outputs:

3) Kůrková I., Bruthans J., Balák F., Slavík M., Schweigstilllová J., Bruthansová J., Mikuš P., Vojtíšek J., Grundloch J. (2019). Factors controlling the evolution of karst conduits in sandy limestone and calcareous sandstone (Turnov area, Czech Republic). *Journal of Hydrology* 574, 1062–1073. doi.org/10.1016/j.jhydrol.2019.05.013

4) Klimeš J., Calvello M., Auflič M.J. (2019). Objectives and main results of “Community Participation for Landslide Disaster Risk Reduction” thematic papers. *Landslides* 16, 1–2. doi.org/10.1007/s10346-019-01246-z

5) Klimeš, J., Rosario, A.M., Vargas, R., Raška, P., Vicuña, L., Jurt, C. (2019). Community participation in landslide risk reduction: a case history from the Central Andes, Peru. *Landslides* 16, 1763-1777. doi.org/10.1007/s10346-019-01203-w

6) Šilhán K., Klimeš J., Tichavský R. (2019). The sensitivity of the dendrogeomorphic approach to landslide movements.

Geomorphology, on-line: doi.org/10.1016/j.geomorph.2019.106869 0169-555X

- 7) Klimeš J., Norabuena E., Stemberk Josef, René M. (2019). Transient compression fault slip detected within the andesitic rocks of the Casma Group, Lima, Peru. *Studia Geophysica et Geodaetica* 63, 257–272. doi.org/10.1007/s11200-018-2912-2
- 8) Balek J., Klimeš J., Blahůt J., Štroner M., Urban R., Hartvich F. (2019). Shallow landslide movements in clay rich rocks detected during a subnormal precipitation period. *Acta Geodynamica et Geomaterialia* 16, 409–417. doi:10.13168/AGG.2019.0034
- 9) Kusák M., Valagussa A., Frattini P. (2019). Key issues in 3D rockfall modelling, natural hazard and risk assessment for rockfall protection in Hřensko (Czechia). *Acta Geodynamica et Geomaterialia* 16, 393–408. doi:10.13168/AGG.2019.0033
- 10) Stemberk Jakub, Coubal M., Stemberk Josef, Štěpančíková P. (2019). Stress analysis of fault slip data recorded in the Dědičná štola Gallery in the Rychlebské hory Mts., NE part of the Bohemian massif. *Acta Geodynamica et Geomaterialia* 16, 315–330. doi:10.13168/AGG.2019.0027
- 11) Vysoká H., Bruthans J., Falteisek L., Žák K., Rukavičková L., Holeček J., Schweigstillová J., Oster H. (2019). Hydrogeology of the deepest underwater cave in the world: Hranice Abyss, Czechia. *Hydrogeology Journal* 27, 2325–2345. doi.org/10.1007/s10040-019-01999-w

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The Department of Neotectonics and Thermochronology focused on tectonic activity along active faults in the Czech Republic and the USA and the seismicity thereof, paleontological conditions in the Bohemian Massif and seismic hazards in the western Himalayas. In cooperation with other geoscience institutions, the department also participated in the research of slope deformations and the structural-tectonic development of sandstone rock clusters both in the Czech Republic and in Poland. The Department enjoys intensive cooperation with the Department of Engineering Geology.

Outputs:

1) The analysis of the results of extensometric measurements employing TM71 instrumentation revealed recurring episodic changes in the stress conditions in the Bohemian Massif. Three TM71 extensometers were installed in the Dědičná mining gallery (Rychlebské Mountains). The measured movement values were used for the calculation of the parameters of the current stress field in the Bohemian Massif. The analysis revealed the repeated alternation of 2 compressions (NW-SE and NNE-SSW) and one extension (NW-SE). It is possible, based on the stress parameters, to assess the dynamics of the behaviour of known faults or, based on geomorphological research, of assumed faults. The faults that have orientations of NW-SE to N-S and NNE-SW may, potentially, be revived by the current stress field. The observations also revealed that these movements were significantly milder in mid-2015.



Illustration of the results from 1): The Dědičná mining gallery in the Rychlebské Mountains was excavated for the exploration of lead-silver ores, the mining of which took place in this area around 1568 and, again, during the 19th century. The mining area was then referred to as the Krautenwald (today Travná) state mine. Automated TM71 extensometers are currently monitoring tectonic micro-movements along three faults in the mining gallery on a daily basis.

Publication:

Stemberk Jakub, Coubal M., Stemberk Josef, Štěpančíková P. (2019). Stress analysis of fault slip data recorded in the Dědičná štola Gallery in the Rychlebské hory Mts., NE part of the Bohemian Massif. *Acta Geodynamica et Geomaterialia* 16, 315–330. doi:10.13168/AGG.2019.0027

2) The analysis of the site response in the Kashmir Valley during the earthquake of 8 October 2005 (Mw = 7.6) employing geotechnical data. The Kashmir Valley is frequently affected by devastating earthquakes, such as the 2005 Mw 7.6 magnitude event. Due to the unavailability of data on the measured strong soil movements during the earthquake, the authors employed borehole data, and determined that local geological conditions play a very important role in the transmission of soil movements from the subsoil to the surface. They emphasise the importance of considering the influence of local conditions as one of the key parameters with respect to the assessment of the seismic hazard in the Kashmir Valley.

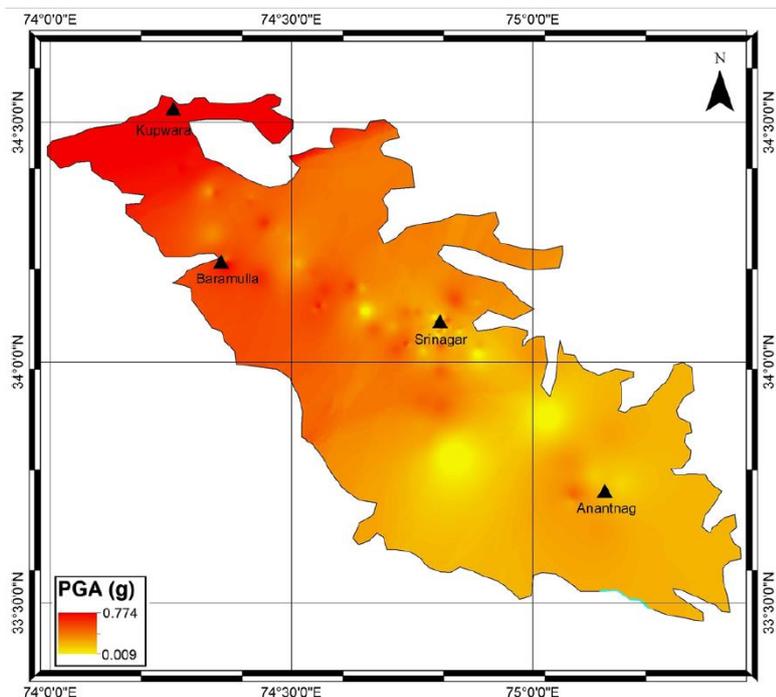


Illustration of the results from 2): Maximum acceleration of the subsoil in the Kashmir Valley during the earthquake of 8 October 2005 (PGA - acceleration in units of g).

Publication:

Sana H., Nath S. K., Gujral K. S. (2019). Site response analysis of the Kashmir valley during the 8 October 2005 Kashmir earthquake (Mw 7.6) using a geotechnical dataset. *Bulletin of Engineering Geology and the Environment* 78, 2551–2563. doi.org/10.1007/s10064-018-1254-1

Further outputs:

3) Coubal M., Zelenka P., Stemberk J. jr. (2019): Record of the Alpine tectonic activity of the Železné hory Fault expressed by brittle deformation within its south-eastern segment. *Geoscience Research Reports* 52 (2), 141–146. doi: 10.3140/zpravy.geol.2019.10

4) Sana H. (2019): A probabilistic approach to the seismic hazard in the Kashmir basin, NW Himalaya. *Geoscience Letters* 6, 5, 1–11. doi.org/10.1186/s40562-019-0136-0

5) Stemberk J., Dal Moro G.C., Stemberk J. jr., Blahut J., Coubal M., Košťák B., Zambrano M., Tondi E. (2019): Strain monitoring of active faults in the central Apennines (Italy) during the period 2002–2017. *Tectonophysics* 750, 22–35. doi.org/10.1016/j.tecto.2018.10.033

6) Štěpančíková P., Fischer T., Stemberk J. jr., Nováková L., Hartvich F., Figueiredo P. M. (2019): Active tectonics in the Cheb Basin: youngest documented Holocene surface faulting in Central Europe? *Geomorphology* 237, 472–488. doi.org/10.1016/j.geomorph.2018.11.007

7) Uxa T., Křížek M., Krause D., Hartvich F., Tábořík P., Kasprzak M. (2019): Comment on the ‘Geophysical approach to the study of a periglacial blockfield in a mountain area (Ztracené kameny, Eastern Sudetes, Czech Republic)’ by Stan et al. (2017). *Geomorphology* 328, 231–237. doi.org/10.1016/j.geomorph.2018.10.010

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The Department of Seismotectonics was engaged in the study of natural seismic phenomena associated with the dynamics and tectonic development of structures in the Earth’s crust, especially in its upper section, as well as seismic phenomena induced by anthropogenic activity. The department developed applications for the assessment of geophysical measurements, monitoring devices and methodologies for the research of seismic activity. Research also addressed the assessment of the seismic threat for nuclear power plants.

Outputs:

1) The seismic structure under the Reykjanes peninsula in southwestern Iceland derived from the dispersion of Rayleigh waves recorded by the local station network.

Nine broadband stations from the REYKJANET seismic network were used to derive the seismic structure aimed at determining the Rayleigh wave phase velocity dispersion. Seismograms from 2013 to 2015 included fourteen selected earthquakes; the dispersion curves were inverted into a horizontally-layered model of the S-wave velocities of the Earth’s crust and upper mantle. A significant zone of low velocities was found at depths above 20 km.

Publication:

Málek J., Brokešová J., Novotný O. (2019). Seismic structure beneath the Reykjanes Peninsula, southwest Iceland, inferred from array-derived Rayleigh wave dispersion. *Tectonophysics* 753, 1–14.
doi:10.1016/j.tecto.2018.12.020

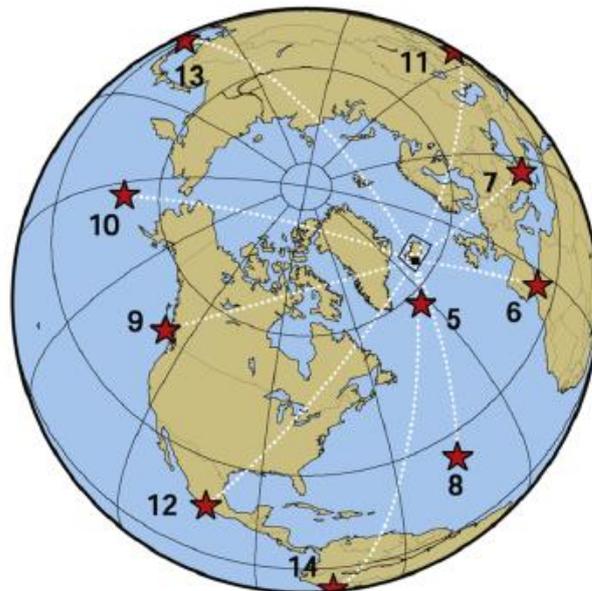
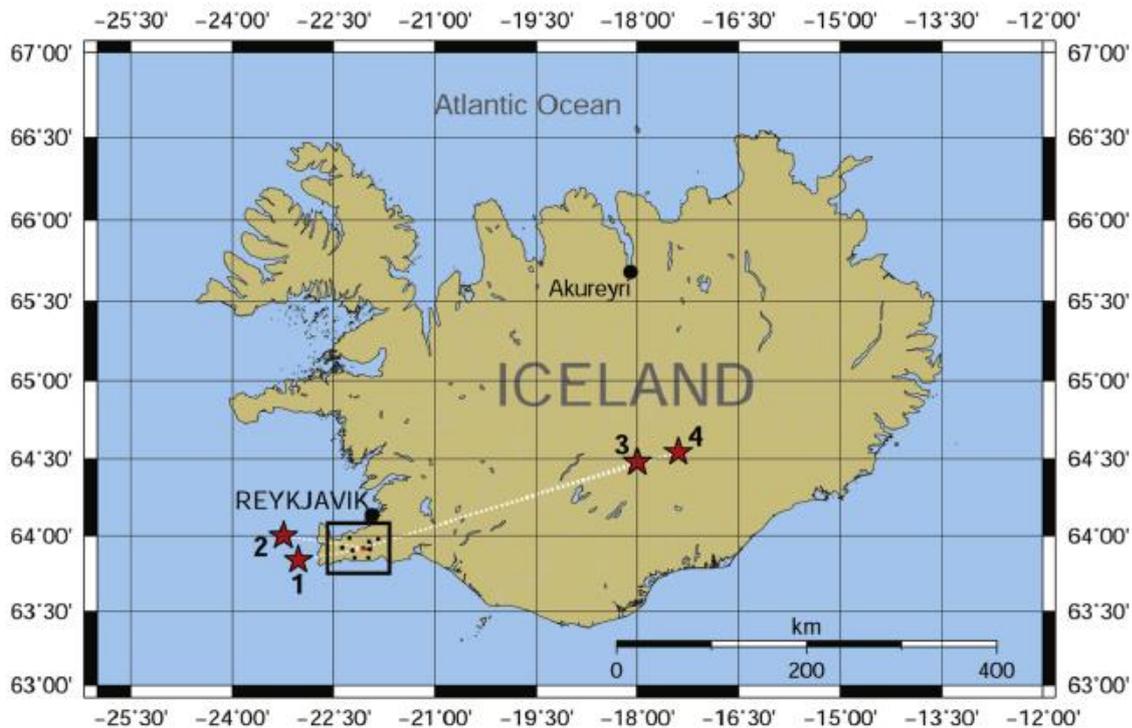


Illustration of the results from 1): The earthquakes used for the compilation of the model. The construction of the model considered 14 earthquakes from 2013 to 2015 with various epicentral distances as recorded by the REYKJANET seismic network.

2) The site-specific probabilistic calculation of the seismic hazard for Prague (Czech Republic). Prague is located in an intra-plate region with low seismicity; while the seismic hazard is low, it is not negligible. The results of the study were obtained using the OpenQuake program, i.e. open software for the calculation of seismic hazards developed as part of the GEM international initiative for the Earth global model. The seismic threat to Prague, expressed via the peak acceleration of soil movements, was determined at below 0.1 g for a return period of 10,000 years.

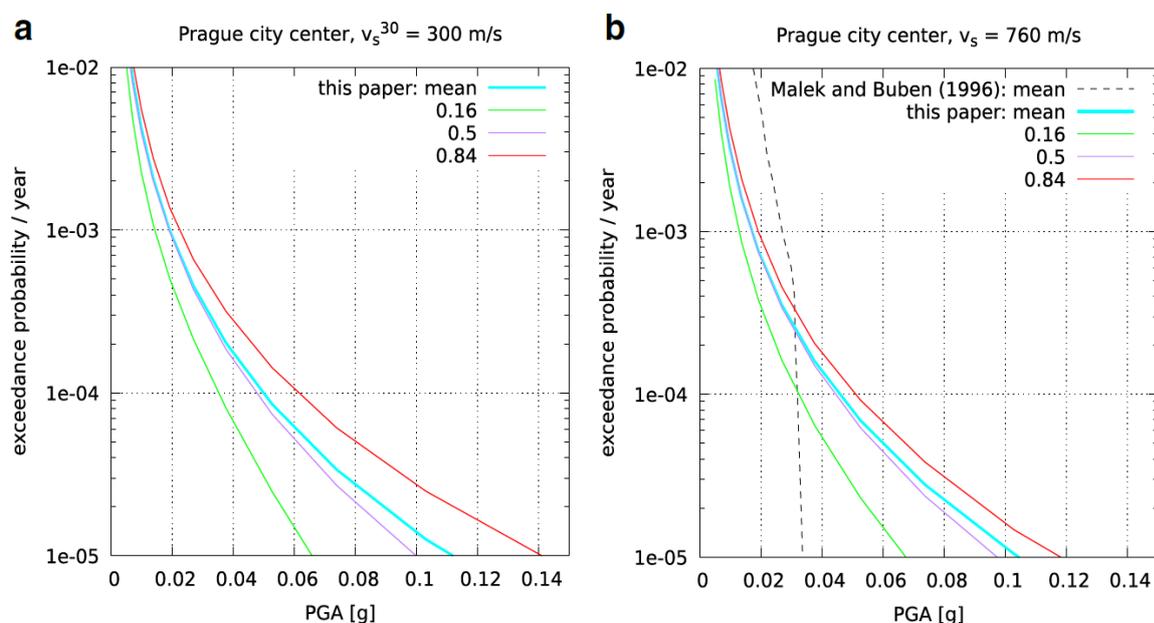


Illustration of the results from 2): Seismic hazard curves for Prague: a) for hard bedrock, b) for river sediments. The graphs present the mean and the 16% and 84% percentile curves.

Publication:

Málek J., Vackář J. (2019). Site-specific probabilistic seismic hazard of Prague (Czech Republic). *Journal of Seismology* 23, 223–1232.
doi:10.1007/s10950-019-09859-6

Further outputs:

- 3) Zábřanová E., Matyska C., Stemberk Jakub, Málek J. (2019). Eigenoscillations and Stability of Rocking Stones: The Case Study of “The Hus Pulpit” in the Central Bohemian Pluton. *Pure and Applied Geophysics*, on-line:
doi.org/10.1007/s00024-019-02296-z
- 4) Lukešová R., Fojtíková L., Málek J., Kolínský P. (2019): Seismic Wave Velocities Inferred From The Surface Wave Dispersion In the Malé Karpaty Mountains, Slovakia. *Acta Geodynamica et Geomaterialia* 16, 451–464.
doi:10.13168/AGG.2019.0038
- 5) Wcislo M., Eisner L. (2019). Fast Determination of Attenuation From Microseismicity for Large Datasets. *Acta Geodynamica et Geomaterialia* 16, 257–268.
doi:10.13168/AGG.2019.0022
- 6) Wandycz P., Swiech E., Eisner L., Pasternacki A., Wcislo M., Mackowski T. (2019). Estimation of the Quality Factor based on the Microseismicity Recordings

Factor based on Microseismicity Recordings from Northern Poland. *Acta Geophysica* 67, 2005–2014. doi:10.1007/s11600-019-00362-7 C

- 7) Dal Moro G., Al-Arifi N., Moustafa S.R. (2019). On the efficient acquisition and holistic analysis of Rayleigh waves: Technical aspects and two comparative case studies. *Soil Dynamics and Earthquake Engineering* 125, 105742. doi.org/10.1016/j.soildyn.2019.105742

8) Utility model:

Málek J. (2019). Container for the deep geological disposal of spent nuclear fuel). Utility model no.: CZ 33053 U1. Industrial Property Office of the Czech Republic.

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The Department of Geochemistry conducted research on (a) the rationalisation of used sorption materials based on activated carbon, (b) the development and preparation of new micro-mesoporous carbon materials - adsorbents for the capture of air pollutants and (c) the surface chemical reactions of selected gaseous analytes on the surface of CuOx nanofibres, used as gas sensors. In addition, the staff of the department cooperated on the results of organic geochemistry, petrology and mineralogy research.

Outputs:

1) The capture of CO₂ employing three-dimensionally arranged micro-mesoporous carbon. The adsorption of CO₂ on a three-dimensionally arranged micro-mesoporous carbonaceous material was studied by means of gravimetric and manometric analysis. Regular spherical mesopores with a large pore volume provided a very high CO₂ adsorption capacity exceeding that of comparable carbon materials at high pressures. The micropores present in the walls of the spherical mesopores exhibited good CO₂ adsorption properties at atmospheric pressure.

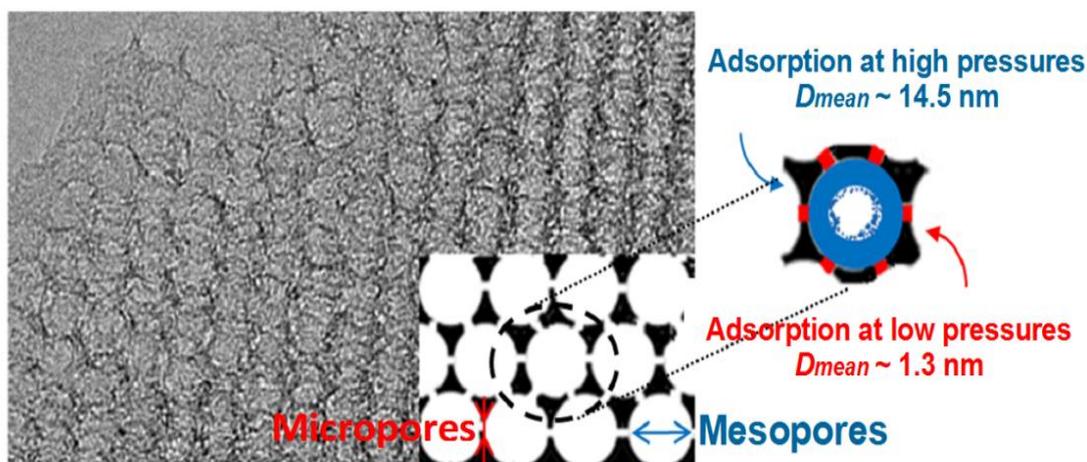


Illustration of the results from 1): Schematic representation of the filling of pores with carbon dioxide in a three-dimensionally arranged micro-mesoporous carbon material at low and high pressures.

Publication:

Vorokhta M., Morávková J., Římnáčová D., Pilař R., Zhigunov A., Švábová M., Sazama P. (2019). CO₂ capture using three-dimensionally ordered micromesoporous carbon, *Journal of CO₂ Utilization* 31, 124–134. doi: org/10.1016/j.jcou.2019.03.001

2) Nb-Ta-Ti oxides from Geyersberg (Germany) topaz granites. Oxide minerals (Nb-Ta rutile, columbite-(Fe) and W-ixiolite) were found to comprise the principal host minerals of Nb, Ta and Ti in the topaz granites of the Geyersberg granite stock in the German part of the Erzgebirge Mountains batholith. Ixiolite was found to contain a significant concentration of Fe and relatively low values of the Mn/(Mn + Fe) and Ta/(Ta + Nb) ratios.

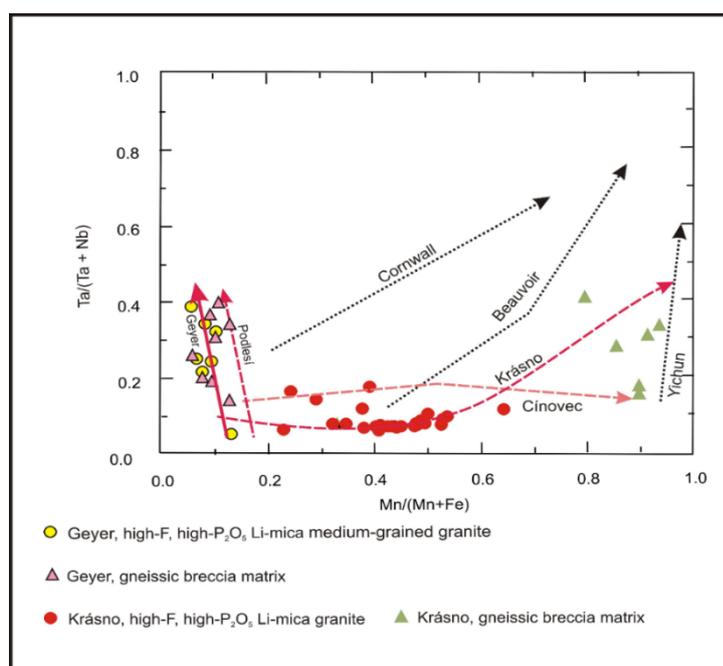


Illustration of the results from 2): Distribution of Ta / (Ta + Nb) and Mn / (Mn + Fe) in the columbite group minerals of selected Sn-W-Nb-Ta deposits.

Publication:

René M. (2019). Nb-Ta-Ti oxides in the topaz granites of the Geyersberg granite stock (Erzgebirge Mts., Germany). *Minerals* 9(3), 155, 1–14. doi: org/10.3390/min9030155

3) The paleo-thermal and coalification history of permo-carbon sedimentary basins in Central and Western Bohemia, Czech Republic: initial findings from apatite fission tracking analysis and the modelling of vitrinite reflectance. The research, and kinetic modelling using apatite fission-track-dating analysis and vitrinite reflectance as additional thermo-chronometers, provided insight into the paleo-geothermal history of the Upper Carboniferous sediments of central-western Bohemia. During the Variscan Permo-carbon thermal culmination, geothermal gradients increased significantly, the coalification process proceeded rapidly, the degree of coalification extended near to the surface, and the coalification of peat occurred between 2 and 4 million years following deposition.

Publication:

Suchý V., Filip J., Sýkorová I., Pešek J., Kořínková D. (2019). Paleo-thermal and coalification history of the Permo-Carboniferous sedimentary basins of Central and

Western Bohemia, Czech Republic: first insights from apatite fission track analysis and vitrinite reflectance modelling. *Bulletin of Geosciences* 94(2), 201–219.
doi:10.3140/bull.geosci.1696

Further outputs:

- 4) Mizera J. (2019). ^{10}Be in Australasian microtektites compared to tektites: Size and geographic controls. *Geology* 47(4), e459. doi.org/10.1130/G45604C.1
- 5) Suchý V., Zachariáš J., Tsai H-Ch., Yu T.-L., Shen Ch.-Ch., Světlík I., Havelcová M., Borecká L., Machovič V. (2019). Relict Pleistocene calcareous tufa of the Chlupáčova sluj Cave, the Bohemian Karst, Czech Republic: A petrographic and geochemical record of hydrologically-driven cave evolution. *Sedimentary Geology* 385, 110–125. doi.org/10.1016/j.sedgeo.2019.03.014
- 6) Kotulová J., Starek D., Havelcová M., Pálková H. (2019). Amber and organic matter from the late Oligocene deep-water deposits of the Central Western Carpathians (Orava–Podhale Basin). *International Journal of Coal Geology* 207, 96–109. doi.org/10.1016/j.coal.2019.02.006
- 7) V. Opletal, E. Geršlová, S. Nehyba, I. Sýkorová, J. Rez (2019). Geology and thermal maturity of Namurian deposits in the Němčičky Subbasin as the South-eastern continuation of the Upper Silesian Coal Basin (Czech Republic). *Intern. Journal of Coal Geology* 216, 103323. doi.org/10.1016/j.coal.2019.103323
- 8) Havelcová M., Machovič V., Špaldoňová A., Lapčák L., Hendrych J., Adam M. (2019). Characterization of Eocene fossil resin from Moravia, Czech Republic: Insights into macromolecular structure. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 215, 176–186. doi.org/10.1016/j.saa.2019.02.058
- 9) Špaldoňová A., Frouz J. (2019). Decomposition of forest litter and faeces of *Armadillidium vulgare* (Isopoda: Oniscidea) produced from the same litter affected by temperature and litter quality. *Forests* 10, 939 (1–11). doi:10.3390/f10110939
- 10) Hodák P., Vorokhta Mykhailo, Khalakhan I., Jarkovská K., Cibulková J., Fitl P., Vlček J., Fara J., Tomeček D., Novotný M., Vorokhta Maryna, Lančok J., Matolínová I., Vrňata M. (2019). New Insight into the gas-sensing properties of CuOx nanowires by near-ambient pressure XPS. *The Journal of Physical Chemistry C* 123, 49, 29739–29749. doi: 10.1021/acs.jpcc.9b09124
- 11) Hodák R., Perrot F., Brudanin V., Busto J., Havelcová M., Hůlka J., Jullian S., Kochetov O., Lalanne D., Loaiza P., Macl J., Mamedov F., Mizera J., Noel R., Piquemal F., Rukhadze E., Rulík P., Smolek K., Soulé B., Suchá T., Světlík I., Štekl I., Warot G., Zampaolo M., Žaloudková M. (2019). Characterization and long-term performance of the Radon Trapping Facility operating at the Modane Underground Laboratory. *Journal of Physics G: Nuclear and Particle Physics* 46(11), 115105. doi:iopscience.iop.org/article/10.1088/1361-6471/ab368e/meta
- 12) René M., Dolníček Z., Sejkora J., Škácha P., Šrein V. (2019). Uraninite, coffinite and ningyoite from vein-type uranium deposits of the Bohemian Massif (Central European Variscan belt). *Minerals* 9(2), 123, 1–21. doi.org/10.3390/min9020123
- 13) Vöröš D., Geršlová E., Nývlt D., Geršl M., Kuta J. (2019). Assessment of geogenic input into Bilina stream sediments (Czech Republic). *Environmental Monitoring and Assessment* 191, 114–125. doi.org/10.1007/s10661-019-7255-0

- 14) René M. (2019). Allanite from granitic rocks of the Moldanubian batholith (Central European Variscan belt). *In the book: Aide M. (Editor), Rare earth elements and their minerals*, IntechOpen, London, pp.1–10. doi: 10.5772/intechopen.86356
- 15) René M. (2019). Titanite from titanite-spots granodiorites of the Moldanubian batholith (Central European Variscan belt). *In the book: Ali Al-Juboury (Editor), Mineralogy*, IntechOpen, London, pp.1–11. doi: 10.5772/intechopen.88359



The Department of Composites and Carbon Materials focused on the study of the properties of collagen-based materials that have the potential for application in the healthcare sector with respect to three main areas, the first of which concerned collagen-calcium phosphate layers saturated with antibiotics, which can be applied directly via electrostatic spinning to the surface of various types of implants. This involved, in particular, the monitoring of the application conditions, which are important for attaining the uniform thickness of the resulting layer and its homogeneity, as well as for maintaining the natural structure of the collagen. All these properties influence the ways in which the antibiotics are released and the layer is broken down in the body; moreover, they are important in terms of the good cohesion of the layers to the surface of metal implants. The second area concerned collagen wound dressings. The studied materials are also suitable for combination with antibiotics so as to achieve the required therapeutic effect, especially in the treatment of chronic wounds and surgery in infectious environments. The way in which the antibiotics are released, their concentration and time of release are, in tandem with programmable degradation, important for achieving effective treatment. Extensive testing has been performed so as to determine the appropriate setup. The third area concerned collagen replacements and patches for use in vascular surgery. Since the mechanical properties of currently used collagen hydrogels are not ideal, the research addressed the improvement thereof via the preparation of hydrogels, the reinforcement of collagen fibres and the use of the action of cells that enables them to transform under static and dynamic conditions into structurally and mechanically suitable materials.

With respect to high-temperature composites, the department focused on the development of hybrid composites with a partially pyrolysed polysiloxane matrix reinforced with silicate fibres. Particular attention was devoted to the study of structural changes resulting from the heating of basalt fibres to over 700°C. A further subject of interest concerned the laboratory preparation of these composites with the use of textiles with various weaves for reinforcement purposes. The resulting material was subjected to mechanical, elevated-temperature and fire testing.

Outputs:

- 1) The precipitation of iron in basalt fibres embedded in a partially pyrolysed methylsiloxane matrix.

One of the fundamental findings of the research was the discovery that crystallisation processes in fibres are affected by the diffusion of pyrolytic gases through the fibre-matrix interface. Further annealing in an oxidising atmosphere significantly altered the crystallisation process, which resulted in a slight improvement in the fracture toughness of the composites. Microstructural changes within the composites were investigated by means of SEM, TEM and Mössbauer spectroscopy. Crystals of

elemental iron were found in the fibres; the formation of pure iron crystals was an unexpected and newly-discovered phenomenon.

Publication:

Halasová M., Kuběna I., Roupcová P., Černý M., Strachota A., Chlup Z. (2019). Iron precipitation in basalt fibres embedded in a partially pyrolysed methylsiloxane matrix. *Composites Part A: Applied Science and Manufacturing* 123, 286–292. doi.org/10.1016/j.compositesa.2019.05.026

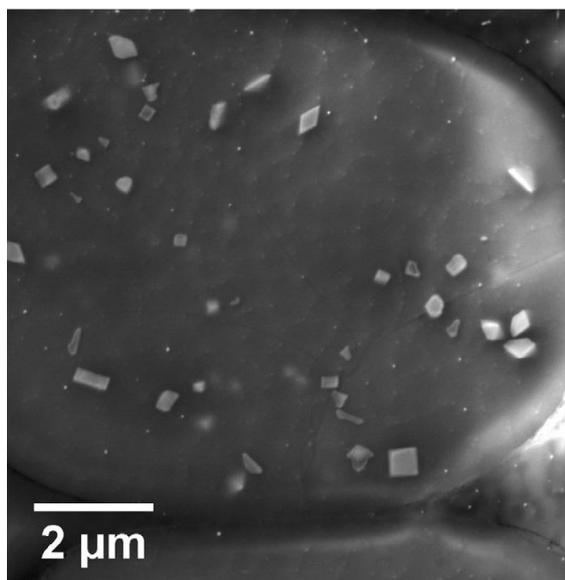


Illustration of the results from 1): The formation of iron crystals in basalt fibres. At temperatures of over 700°C, crystalline iron phases began to appear in the originally purely amorphous basalt fibres, thus leading to changes in the mechanical behaviour.

Further outputs:

- 2) Šťastný P., Sedláček R., Suchý T., Lukášová V., Rampichová M., Trunec M. (2019). Structure degradation and strength changes of sintered calcium phosphate bone scaffolds with different phase structures during simulated biodegradation *in vitro*. *Materials Science and Engineering: C* 100, 544–553. doi.org/10.1016/j.msec.2019.03.027
- 3) Vojtová L., Michlovská L., Valová K., Zboncak M., Trunec M., Částková K., Krtička M., Pavlíňáková V., Poláček P., Dzurov M., Lukášová V., Rampichová M., Suchý T., Sedláček R., Ginebra M.P., Montufar E.B. (2019). The effect of the thermosensitive biodegradable PLGA-PEG-PLGA copolymer on the rheological, structural and mechanical properties of thixotropic self-hardening tricalcium phosphate cement. *International Journal of Molecular Sciences* 20(2), 391, 1–21. doi.org/10.3390/ijms20020391
- 4) Lambert L., Novakova M., Lukac P., Cechova D., Sukenikova L., Hrdy J., Mlcek M., Chlup H., Suchý T., Grus T. (2019). Evaluation of the immunogenicity of a vascular graft covered with collagen derived from the european carp (*Cyprinus carpio*) and bovine collagen. *Biomed Research International*, Article ID 5301405, 1–8. doi.org/10.1155/2019/5301405

- 5) Lukáč P., Hartinger J., Mlček M., Popková M., Suchý T., Šupová M., Závora J., Adámková V., Benáková H., Slanař O., Bartoš M., Chlup H., Lambert L., Grus T. (2019). A novel gentamicin-releasing wound dressing prepared from freshwater fish *Cyprinus carpio* collagen cross-linked with carbodiimide. *Journal of Bioactive and Compatible Polymers* 34(3), 246–262. doi.org/10.1177/0883911519835143
- 6) Sauerová P., Suchý T., Šupová M., Bartoš M., Klíma J., Juhásová J., Juhás S., Kubíková T., Tonař Z., Sedláček R., Piola M., Fiore G., Soncini M. (2019). Positive Impact of Dynamic Seeding of Mesenchymal Stem Cells on Bone-like Biodegradable Scaffolds with Increased Content of Calcium Phosphate Nanoparticles. *Molecular Biology Reports* 46(4), 4483–4500. doi:10.1007/s11033-019-04903-7
- 7) Mitas P., Grus T., Lambert L., Mlcek M., Chlup H., Honsova E., Dohnalova M., Suchý T., Burgetova A., Lindner J., Spacek M. (2019). The Influence of the Purification of Carp Collagen Used in a Novel Composite Graft with Sandwich Construction of the Wall on Its Biological Properties and Graft Patency Rates. *Physiological Research* 68(4), 603–610. doi.org/10.33549/physiolres.934117



The Department of Material Structures and Properties modelled melting processes with concern to research into glass and glass technologies, focusing particularly on the development of new smelters, the high-temperature monitoring of inhomogeneities in glass melts, the vitrification of radioactive waste and the preparation of infrared-permeable glasses (chalcogenide and heavy metal oxide glasses) and the characterisation thereof. The research of geopolymer materials concentrated on the investigation of the potential for the liquidation of the harmful polyaromatic hydrocarbons contained in the ash produced via the imperfect combustion of straw and the potential for the use of such ash as a filler material in metakaolin-based geopolymers. As part of the AV21 Strategy “New materials based on metals, ceramics and composites”, the department addressed issues surrounding the repair of reinforced concrete using special geopolymer mixtures. Other activities focused on the summarisation and assessment of the results obtained over the last two decades concerning the use of neodymium materials with magnetic properties in the treatment and purification of raw materials.

The issue of waste treatment was addressed in the context of both the AV21 Strategy “Efficient Energy Conversion and Storage” and a TACR project. The research investigated the thermal decomposition of various types of biomass and the use of the resulting products as a clean fuel or a source of chemicals, and issues surrounding the transformation of sewage sludge into fertilisers with increased phosphorus contents. The material and energy balances of a number of discontinuously controlled processes and the characteristics of the output products were subsequently determined.

Outputs:

1) The creation of strong magnetic fields from neodymium magnets and their use in industrial practice.

The results of the basic and applied research of strong magnetic fields and their use in industry obtained by Institute researchers over the last twenty years were summarised in the form of an extensive review that documented, *inter alia*, the use of developed and constructed magnetic separators and filters in the production lines of large industrial companies such as Lasselsberger, Laufen and Elektroporcelán a.s. and for research purposes at Czech and Slovak technical universities, e.g. the Technical Universities of Ostrava and Košice.



Illustration of the research from 1): the industrial installation of a magnetic filter with Nd-Fe-B magnets for dual-stage magnetic filtration in a production line for the preparation of sanitary ceramic glazes (Laufen).

Publication:

Straka P., Žežulka V. (2019). Linear structures of Nd-Fe-B magnets: Simulation, design and implementation in mineral processing – A review. *Minerals Engineering* 143 (2019) 105900. doi.org/10.1016/j.mineng.2019.105900

2) The synthesis and characterisation of geopolymers based on metakaolin and ash produced via the imperfect combustion of straw (ash with high ignition losses).

Ash produced via the imperfect combustion of straw was used as a filler in metakaolin-based geopolymers. It was found that geopolymer bonds are formed even following the addition of the ash, and that the addition of 33% by weight of ash significantly reduces the setting time of the mixture from 720 to 120 minutes; however, it was also determined that the compressive strength of the resulting material is adversely affected by the addition of the ash. The polyaromatic hydrocarbons (PAHs) contained in the ash as pollutants were found to be largely inhibited within the geopolymer structure.

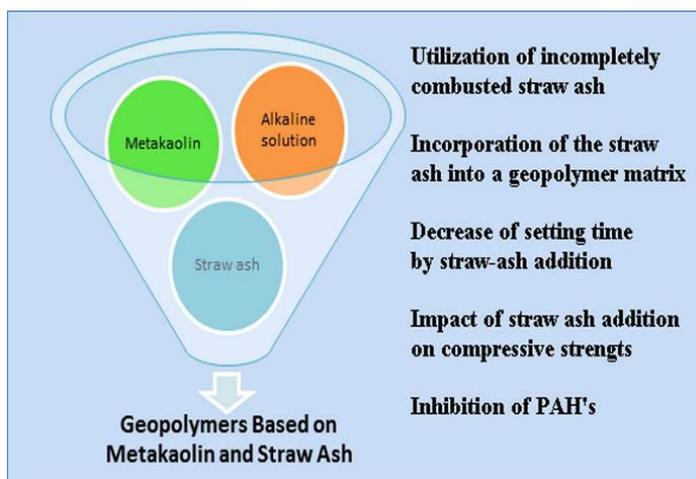


Illustration of the results from 2): The use of ash produced via the imperfect combustion of straw: the incorporation of ash into the geopolymer matrix in the presence of alkalis reduced the solidification time, affected the compressive strength of the resulting material and inhibited pollutants.

Publication:

Perná I., Šupová M., Hanzlíček T., Špaldoňová A. (2019). The Synthesis and Characterization of Geopolymers Based on Metakaolin and high LOI Straw Ash. *Construction and building material* 228, 116765. doi.org/10.1016/j.conbuildmat.2019.116765

3) Electro-optical glass for light modulators.

Light modulators are used to process optical signals, while allowing for the control of the phase, frequency, amplitude and polarisation of the transmitted beam. Glass with a sufficiently high electro-optical coefficient is required for the construction of efficient optical modulators that operate in the visible and near-infrared region. Heavy metal oxide glass based on the $\text{PbO-Bi}_2\text{O}_3\text{-Ga}_2\text{O}_3$ ternary system is characterised by high optical sensitivity, and its thermal stability is enhanced via treatment with Ag_2O and Sb_2O_3 . It was determined that such glass is permeable to infrared radiation up to $7.4 \mu\text{m}$ and that it has a high refractive index (up to 2.487 at the wavelength of light used at 473 nm), which also indicates its high ability to polarise light. The resulting electro-optical coefficient was determined at $7.47 - 7.77 \times 10^{12} \text{m} \times \text{V}^{-2}$, which is high enough for the construction of an electro-optical modulator. This value can be further increased by Ag nanoparticles created via the reduction of Ag^+ ions by Sb^{3+} ions.

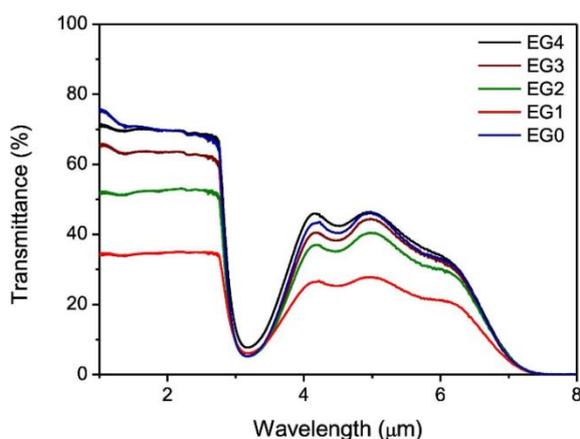
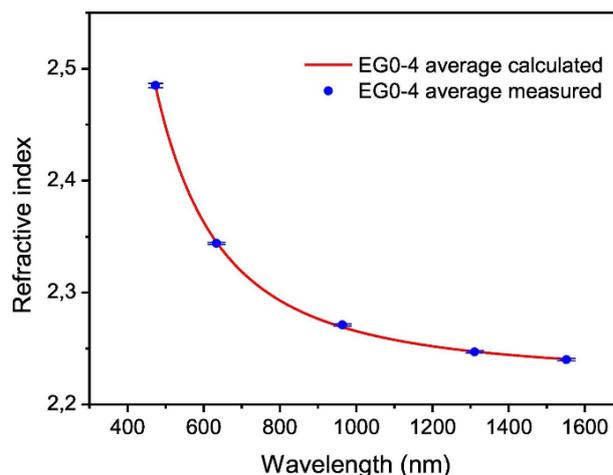


Illustration of the results from 3): The permeability of glass with the $\text{PbO-Bi}_2\text{O}_3\text{-Ga}_2\text{O}_3$ ternary system and treated with Ag_2O and Sb_2O_3 in terms of infrared radiation.

Further illustration of the results from 3):
The refractive index as a function of the wavelength in the visible and near-infrared region.



Publication:

Jílková K., Míka M., Kostka P., Lahodný F., Nekvindová P., Jankovský O., Bureš R., Kavanová M. (2019). Electro-optic glass for light modulators. *Journal of Non-Crystalline Solids* 518, 51–56. doi.org/10.1016/j.jnoncrysol.2019.05.014

Further outputs:

- 4) Hujová M., Kloužek J., Cuthforth D.A., Lee SM., Miller M.D., McCarthy B.P., Hrna P., Kruger A.A., Pokorný R. (2019). Cold-cap formation from a slurry feed during nuclear waste vitrification. *Ceramics International* 45, 6405–6412. doi.org/10.1016/j.ceramint.2018.12.127
- 5) Appel C.J., Kloužek J., Nikhi J., Lee SM., Dixon D.R., Hrna P., Pokorný R., Schweiger M.J., Kruger A.A. (2019). Effect of sucrose on foaming and melting behavior of a low-activity waste melter feed. *Journal of the American Ceramic Society* 102, 7594–7605. doi.org/10.1111/jace.16675
- 6) Lee SM., Hrna P., Pokorný R., Kloužek J., Eaton W.C., Kruger A.A. (2019). Glass production rate in electric furnaces for radioactive waste vitrification. *Journal of the American Ceramic Society* 102, 5828–5842. doi.org/10.1111/jace.16463
- 7) Hrna P., Kloužek J., Pokorný R., Lee S.M., Kruger A.A. (2019). Heat transfer from glass melt to cold cap. Gas evolution and foaming. *Journal of the American Ceramic Society* 102, 5853–5865. doi.org/10.1111/jace.16484
- 8) Lee SM., McCarthy B.P., Hrna P., Chun J., Pokorný R., Kloužek J., Kruger A. (2019). Viscosity of glass-forming melt at the bottom of high-level waste melter-feed cold caps: effects of temperature and incorporation of solid components. *Journal of the American Ceramic Society*. doi.org/10.1111/jace.16876
- 9) Pokorný R., Hrna P., Lee SM., Kloužek J., Choudhary M., Kruger A. (2019). Modeling batch melting: Roles of heat transfer and reaction kinetics. *Journal of the American Ceramic Society*. doi.org/10.1111/jace.16898
- 10) Kostka P., Ivanova Z.G., Nouadji M., Černošková E., Zavadil J. (2019). Er-doped antimonite Sb_2O_3 -PbO-ZnO/ZnS glasses studied by low temperature photoluminescence spectroscopy. *Journal of Alloys and Compounds* 780, 866–872. doi.org/10.1016/j.jallcom.2018.11.361
- 11) Jebavá M., Hrbek L., Němec L. (2019). Energy distribution and melting efficiency in glass melting channel: Effect of heat losses, average melting temperature and

- melting kinetics. *Journal of Non-Crystalline Solids* 521, 119478. doi.org/10.1016/j.jnoncrysol.2019.119478
- 12) Lee SM., Hřma P., Pokorný R., Traverso J.J., Kloužek J., Schweiger M.J., Kruger A.A. (2019). Heat transfer from glass melt to cold cap: Effect of heating rate. *International Journal of Applied Glass Science* 10, 401–413. doi.org/10.1111/ijag.13104
- 13) Hřma P., Pokorný R., Lee S., Kruger A.A: Heat Transfer from Glass Melt to Cold Cap: Melting Rate Correlation Equation (2019). *International Journal of Applied Glass Science* 10, 143–150. doi.org/10.1111/ijag.12666
- 14) Bosák O., Castro A., Labaš V., Trnovcová V., Kostka P., Calvez L., Le Coq D., Kubliha M. (2019). Influence of NaI Additions on the Electrical, Dielectric, and Transport Properties in the GeS₂–Ga₂S₃–NaI Glass System. *Russian Journal of Electrochemistry* 55, 501–509. doi.org/10.1134/S1023193519060053
- 15) Utility model:
 Němec L., Hrbek L., Jebavá M., Brada J. (2019). Schmelzraum eines kontinuierlichen Glass-schmelzofens und nach einem darin ausgeführtem Verfahren erhaltene Glass-schmelze. Gebrauchsmusterschrift DE 20 2018 105 160 U1, 2019.02.14, Deutsches Patent- und Markenamt, München.

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All the Institute's scientific departments continued their efforts to popularise the results of their research at exhibitions, as part of the ASCR Science and Technology Week and via lectures and articles for the public with visual presentations (see the illustration photograph and section 7).



Illustrative photograph: In the Peruvian mountains, scientists are investigating the behaviour of landslides and rock avalanches, which are becoming increasingly common due to melting ice. They pose a significant danger to the local population and cause considerable damage.

3. Research projects conducted by the Institute's scientific departments in 2019

Projects financed by the Grant Agency of the Czech Republic (GACR):

- Infrared transmissive glass based on heavy metal oxides.
- Fundamental aspects of the partial pyrolysis of hybrid composites with polysiloxane matrix precursors.
- Resistance to brittle failure: the importance of petrographic/mechanical data for the technological-mechanical properties and durability of crushed stone.
- The radiolytic alteration of organic matter in a uranium-bearing medium.
- Physical processes associated with swarm seismicity at the interface of tectonic plates in southern Iceland and earthquake swarms in western Bohemia/Vogtland.
- The stress- and hydraulic field-controlled weathering and erosion of granular rocks.

Projects financed by the Technology Agency of the Czech Republic (TACR):

- Advanced glass production technologies.
- The material transformation of sewage sludge into fertiliser with increased phosphorus content.
- The rationalisation of the handling of used sorption materials based on activated carbon.

Infrastructure support research projects and the coordination of professional activities:

- EPOS/CzechGeo - Observatory and geophysical field measurement distribution system in the Czech Republic (national node of the ESFRI/EPOS project).
- RINGEN - Geothermal energy research infrastructure.
- Representation of the Czech Republic in the management of the ICL through the Centre of Excellence.

4. Cooperation with universities

With respect to educational programmes, IRSM staff taught 143 hours and 123 hours in connection with bachelor's and master's courses respectively during the summer semester, and 220 hours, 133 hours and 14 hours concerning bachelor's, master's and doctoral courses respectively during the winter semester. The Institute hosted 16 doctoral students, 2 of them from abroad. In addition, Institute staff were involved in the teaching of a number of subjects, especially at the Faculty of Natural Sciences of the Charles University, the Faculty of Mechanical Engineering of the Czech Technical University, the Faculty of Chemical Technology of the University of Chemistry and Technology, the Faculties of Natural Sciences of the Masaryk University in Brno, the University of Ostrava and the Jan Evangelista Purkyně University in Ústí nad Labem and the Faculty of Education of the University of West Bohemia in Pilsen, as well as a number of foreign institutions including the Universidad Nacional de Córdoba, Argentina - Facultad de Ciencias Exactas, Físicas y Naturales.

The Institute operates joint facilities with two universities, i.e. the Faculty of Natural Sciences of the Charles University and the University of Chemistry and Technology, Prague. The staff of the Institute also participated in 4 doctoral study assessment committees during the year at the University of Chemistry and Technology, Prague, the Technical University of Ostrava and the Charles University - Faculty of Natural Sciences.

In 2019, the IRSM concluded an important agreement with the Faculty of Mathematics and Physics of the Charles University on mutual cooperation concerning a doctoral study course - the Physics of the Earth and Planets programme, that will be taught both full- and part-time.

5. Contractual servicesContracts:

1) Commissioned by: UJP Praha a.s.

Contract: The pre-hydridation of Zr1Nb alloy samples.

The research identified the effect of hydrogen on the corrosion properties of nuclear fuel covering tubes. In order to identify the effect of absorbed hydrogen on the

corrosion properties of the Zr alloy of nuclear fuel covering tubes, a set of 90 test specimens with the required hydrogen concentrations of 1000, 600 and 300 ppm was prepared. The hydridation of the zirconium alloy was performed via the application of an original method developed by the IRSM (employing sorption microbalances) that makes use of the accuracy and sensitivity of the weighing system, the potential for its evacuation to high vacuum rates, the potential to vary the temperature and pressure conditions and the ability to terminate hydridation once the required weight gain has been attained.

Application: The prediction of the behaviour of nuclear fuel covering tubes based on Zr alloys as the first nuclear fuel protection layer.

2) Commissioned by: Technical University of Košice, BERG Faculty.

Contract: Magnetic filter for the purification of raw materials.

A magnetic filter for the purification of raw materials by means of the highly efficient magnetic separation of unwanted metal impurities using neodymium permanent magnets was assembled, tested and supplied to the client.

Application: The purification of raw materials without the consumption of electricity.

3) Commissioned by: ČEZ a.s.

Contract: The compilation of a database of faults and the preparation of a methodological manual for the comprehensive assessment of faults as part of the seismic hazard assessment process.

An interim report concerning progress on this ČEZ a.s. project, awarded under the SIGMA 2 international programme, focused on the compilation of a faults database and a methodological manual for the comprehensive assessment of faults.

Application: The assessment of the seismic hazard for buildings and sites.

4) Commissioned by: ČEZ a.s.

Contract: Methodology for the calculation of the seismic hazard for nuclear power plants.

Methodology for the calculation of the seismic hazard for the Dukovany and Temelín nuclear power plants was created as part of a SIGMA2 international project.

Application: Assessment of the seismic hazard for nuclear power plants.

5) Commissioned by: Czech Radioactive Waste Repository Authority (SÚRAO).

Contract: Monitoring of the seismic activity at the Richard radioactive waste repository site.

Seismic activity at the Richard radioactive waste repository near the town of Litoměřice was monitored and the results were submitted to the client in the form of half-yearly and annual reports.

Application: The safety of radioactive waste repositories.

6) Commissioned by: Brenntag CR s.r.o. (Ing. Aleš Trpišovský).

Contract: The sieve analysis of an activated carbon sample.

The sieve analysis of an activated carbon sample was performed that demonstrated the presence of particles larger than 80 µm.

Application: The inspection of materials for water and air purification purposes.

Cooperation with public administration authorities:

7) A system for the monitoring of the movement of rock blocks on the Branická skála (rock face) in Prague was installed for the Prague 4 City Hall. It serves to protect the public from accidents and injuries and for safety surveillance purposes.

Expertise:

8) Commissioned by: Ředitelství silnic a dálnic ČR (Czech Highways Authority)

Expertise: Monitoring of the D8 motorway.

The IRSM conducted an evaluation of the stability of slopes and the overall safety of the motorway for the D8 Motorway Monitoring Council.

9) Commissioned by: Prague 5 District Court

Expertise: Expert opinion on the assessment of the causes of a landslide on the D8 motorway in 2013.

A report was prepared on the causes of the landslide in July 2013 on the D8 motorway and an evaluation was submitted on the various assessments prepared on this issue.

10) Commissioned by: City of Cheb.

Expertise: The monitoring of the stability of a local road adjacent to property 1529/7 at Starý Hrozňatov.

A potentially unstable section of this local asphalt road with a length of approximately 40 m was monitored.

11) Commissioned by: Spolchemie, a.s.

Expertise: Survey of the terrain surface at the reclaimed Chabařovice landfill site and an evaluation of changes in the period 2015 - 2019.

A detailed digital model of the Chabařovice landfill site was created in order to identify and evaluate changes in the relief in the period 2015 - 2019 and the significance of these changes for the stability of the landfill mass.

12) Commissioned by: City of Karlovy Vary.

Expertise: Expert opinion on the state and progress of slope stabilisation behind the Čas cinema.

Documentation and the adopted procedure concerning the stabilisation of the slope were subjected to assessment.

13) Commissioned by: Lesy České republiky, s.p. (Czech Forestry Authority)

Expertise: The analysis of sandstone rock falls in the Robečský stream valley and the assessment of the stability of the rock blocks above a hiking path.

Reconnaissance work was conducted and photo documentation made of the fallen rock blocks in two field campaigns. The blocks were measured and an assessment made of their stability in their present position. Furthermore, the remaining part of the rock outcrop was inspected and its stability evaluated.

14) Commissioned by: Ředitelství silnic a dálnic ČR (Czech Highways Authority)

Expertise: The evaluation of the current stability of the valley slopes beneath the Šmejka bridge and an assessment of the potential occurrence of slope movements.

An evaluation of the current stability situation in the valley beneath the Šmejka bridge of the D1 motorway was performed and the risks of potential slope movements assessed. Moreover, a proposal was submitted concerning the approach to the stability of slopes during the construction of service roads.

6. International cooperation

The Institute worked on 4 international projects, organised 3 conferences with international participation and was a party to 10 bilateral agreements on scientific cooperation with foreign partners in 2019. The staff of the Institute were active during the year in a number of international scientific organisations; in two cases in official organisational positions.

International projects:

- 1) Identification of Dispersed Organic Matter.
Umbrella organisation: International Committee for Coal and Organic Petrology (ICCP).
- 2) The evaluation of self-heating on coals of different rank via optical microscopy.
Umbrella organisation: International Committee for Coal and Organic Petrology (ICCP).
- 3) INTER-VECTOR - Czech representative in the management of the ICL through the Centre of Excellence, 2019 – 2021.
- 4) LTA-USA19083 - Six-component continuous monitoring of seismic swarms and other earthquakes in the region of the Long Valley Caldera, California.

Events involving international participation organised or co-organised by the IRSM:

- 1) Český ráj 19': State of geomorphological research in 2019, Pařezská Lhota, 3 – 5 April 2019.
- 2) INQUA Summer school on Active Tectonics and Tectonic Geomorphology, Prague, 24 – 27 September 2019.
- 3) 17th Conference on the Electric Melting of Glass, Prague, 10 September 2019.

Official positions in the membership of international organisations:

- 1) Doc. Ing. Jaroslav Kloužek, CSc.: International Commission on Glass, Technical Committee No. 18 – Glass melting. Chairperson, term of office: 2016 – 2020.
- 2) RNDr. Petra Štěpančíková, PhD: International Union for Quaternary Research, Commission on Terrestrial Processes, Deposits, and History, Focus group: Earthquake Geology and Seismic Hazard. Vice-chairperson, term of office: 2016 – 2019.
- 3) RNDr. Petra Štěpančíková, PhD: International Union for Quaternary Research, Commission on Terrestrial Processes, Deposits, and History.

Vice-chairperson, term of office: 2019 – 2023.

Bilateral cooperation with foreign partners:

- 1) Instituto Geofísico del Peru.
Theme of cooperation: Monitoring of tectonic movements.
- 2) Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano.
Theme of cooperation: The development and comprehensive evaluation of composite carriers of mesenchymal stem cells.
- 3) Laboratory of Mechanics of Polymers and Composite Materials, Institute of Macromolecular Compounds, Russian Academy of Sciences.
Theme of cooperation: The preparation and evaluation of composite materials based on collagen, chitosan and calcium phosphate.
- 4) Instituto Nacional de Investigación en Glaciares y Ecosistemas de las Montaña (Peru).
Theme of cooperation: The evaluation of the danger of slope movements around the village of Rampac Grande, Cordillera Negra, Peru.
- 5) Institute of Geophysics, Polish Academy of Sciences.
Theme of cooperation: Research of tectonic movements and slope deformations on the Svalbard archipelago.
- 6) Politecnico di Milano.
Theme of cooperation: The monitoring of fluvial dynamics using the Radio Frequency Identification method.
- 7) University di Salerno.
The training of students in the geoscience activities underway at the IRSM.
- 8) Battelle Energy Alliance, LLC, Idaho.
Theme of cooperation: Batch-to-Glass Conversion and Chemical Durability of Glass for Vitrification of Low Activity Waste (Contract No. 206349).
- 9) Battelle Energy Alliance, LLC, Idaho.
Theme of cooperation: Mathematical Modelling and Experimental Evaluation of Melter Cold Cap for Nuclear Waste Vitrification (Contract No. 166789).
- 10) Uniwersytet Wroclawski.
Theme of cooperation: The research of the structural-geological conditions and the formation of the Broumovsko/Góry Stolowe table mountains.

7. Popularisation and public education activities

- 1) ASCR Science and Technology Week
 - The presentation of the use of waste inorganic and organic materials; the preparation of new geopolymer materials and their properties; types of waste organic materials, their heat treatment and the subsequent use of the solid, liquid and gaseous products; the viscosity of oils.
 - Presentation “There’s no pore like a pore”. A description of experiments on, and the teaching of, the theory of pores, porous materials, natural resources and the cleaning of pollutants from the environment.
 - Lecture: “15 years of research in Peru”.

- The screening of the film “Landslides” from the Silent Threats series and a discussion with the audience. Prague, IRSM 13 - 15 November 2019.

2) Science Fair 2019

- The preparation and application of composite materials based on natural components such as collagen and calcium phosphates; examples of preparation methods.
- Exhibition stand with a presentation of the activities of the Department of Neotectonics and Thermochronology.
- Presentation of the activities of the Department of Engineering Geology. PVA EXPO Prague, Letňany, 7 – 9 June 2019.

3) Exhibition: Right to the Bone!

The exhibition on bones as one of the most important building blocks of the human body presented the structure and function of bones and the ways in which they can be replaced when they are damaged. The exhibition was divided into three parts, the first of which introduced the structure, composition and function of bones. In the second part of the exhibition, visitors were informed of various bone diseases and injuries. The third part described the various approaches to, and the materials used in, the replacement of damaged bones from the beginning of the 20th century to the modern implants of today. The exhibition also mapped the history of companies engaged in the development and production of bone substitutes in the Czech Republic. Brno, 4 - 29 September 2019.

4) Landslides in Peru

A lecture presented by Dr. Klimeš (Department of Engineering Geology) on landslides and slope deformations in Peru. Masaryk public library, Vsetín, 12 March 2019.

5) Presentation of the research and equipment of the Environmental Technologies Laboratory, Department of Material Structures and Properties

A presentation of the commercial potential of physico-chemical and mechanical analysis. Prague, IRSM ASCR, 28 August 2019, 16 October 2019 and 6 November 2019.

6) Articles in the Vesmír magazine

“The negative impacts of landslides”, author: Jan Klimeš, Vesmír 98, 560, 2019/10.

“The positive aspects of landslides”, authors: Jan Klimeš, Ivo Baroň and Lukáš Spitzer, Vesmír 98, 2019/10.

“Danger lurks beneath your feet. The discovery of the youngest large earthquake in the Bohemian Massif”, author: Petra Štěpančíková, Vesmír 98, 296, 2019/5.

8. Network monitoring

Monitoring 1.

TecNET:

Slow movements along tectonic faults.

Provider: IRSM

Programme: RI / OP VVV

Reason for involvement: Monitoring of aseismic tectonic movements along faults.

Monitoring 2.

SlopeNet:

Monitoring of slope deformations.

Provider: IRSM

Programme: CzechGeo/EPOS

Reasons for involvement: The geophysical and geotechnical monitoring of slope deformations. Active involvement in the research and a co-responsibility role.

Monitoring 3.

Monitoring of the EU TecNet network:

3D monitoring of tectonic structures in the EU.

Provider: IRSM

Programme: CzechGeo/EPOS

Reasons for involvement: Meter readings, service and data evaluation.

Monitoring 4.

Czech regional seismic network:

Earthquakes in Europe and worldwide.

Providers: Geophysical Institute ASCR, IRSM, Institute of Geonics ASCR, Institute of Earth Physics, Charles University

Programme: CzechGeo/EPOS

Reason for involvement: The basic earthquake research scientific infrastructure, especially with concern to long-term seismicity research in Europe and worldwide.

Monitoring 5.

MKNET:

Earthquakes in the Little Carpathians in Slovakia.

Providers: IRSM, Institute of Earth Physics of the Slovak Academy of Sciences, Progseis s.r.o.

Programme: Czechgeo/Epos

Reason for involvement: Detailed research in this seismically active area.

Monitoring 6.

REYKJANET – Iceland:

Earthquakes in Iceland.

Providers: Geophysical Institute ASCR, IRSM

Programme: CzechGeo/EPOS

Reason for involvement: Detailed long-term international research in the seismically active area of Iceland.

Monitoring 7.

Geonas:

Movements of GNSS fixed points.

Provider: IRSM

Programme: RI / OP VVV

Reason for involvement: The monitoring of tectonic movements.

9. Published periodicals

- 1) *Acta Geodynamica et Geomaterialia*, Vol. 16, Nos. 1 – 4, 2019, ISSN 1214-9705 (Print); 2336-4351 (On-line). Impact journal, published quarterly. Monitored by the databases: Science Citation Index Expanded; Journal Citation Reports/Science Edition.
- 2) *Ceramics-Silicates*, Vol. 63, Nos. 1 – 4, 2019, ISSN 0862-5468 (Print); ISSN 1804-5847 (On-line). Impact journal, published quarterly. Monitored by the databases: Science Citation Index; Materials Science Citation Index; the Engineering Index (Published by Engineering Information Inc.).

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Further sections of the Annual Report:

Financial statements: Profit and loss statement, 2019

Institute of Rock Structure and Mechanics of the CAS, v. v. i., V Holešovičkách 41, 182 09 Prague 8,
Czech republic

Profit and loss statement

ID number		Balance as at 31. 12. 2019			According to Decree No. 504/2002 Coll.	
67985891		(in Czech Crowns, the comma separates two decimal places)				
Item		Row	Activities			
Number	Designation		Main aktivita/CZK	Supplementary aktivita/CZK	Total/CZK	
A	A. Expenses					
A.I	I. Consumed purchases and purchased services	002	20 126 179,17	1 672 873,21	21 799 052,38	
A.I.1	1. Consumption of material, energy and other non-inventory items	003	7 716 712,59	631 227,70	8 347 940,29	
A.I.3	3. Repairs and maintenance	005	3 109 292,85		3 109 292,85	
A.I.4	4. Travel expenses	006	2 333 417,49	75 151,18	2 408 568,67	
A.I.5	5. Representation costs	007	36 812,52		36 812,52	
A.I.6	6. Other services	008	6 929 943,72	966 494,33	7 896 438,05	
A.II	II. Changes in inventories by their own activities and activation	009	1 590,82		1 590,82	
A.II.8	8. Activation of material, goods and interior services	011	1 590,82		1 590,82	
A.III	III. Total personnel expenses	013	59 110 764,00	1 171 805,00	60 282 569,00	
A.III.10	10. Wages and salaries	014	43 700 063,00	891 252,00	44 591 315,00	
A.III.11	11. Statutory social insurance	015	14 295 712,00	263 477,00	14 559 189,00	
A.III.13	13. Statutory social expenses	017	1 114 989,00	17 076,00	1 132 065,00	
A.IV	IV. Total taxes and fees	019	52 296,00		52 296,00	
A.IV.15	15. Taxes and fees	020	52 296,00		52 296,00	
A.V	V. Total other expenses	021	1 078 978,33	606 194,79	1 685 173,12	
A.V.19	19. Exchange rate losses	025	40 269,62		40 269,62	
A.V.22	22. Other expenses	028	1 038 708,71	606 194,79	1 644 903,50	
A.VI	VI. Total depreciation expenses, sold assets, addition and utilization to reserves and adjustments	029	14 795 053,37		14 795 053,37	
A.VI.23	23. Depreciation expenses of fixed assets	030	14 795 053,37		14 795 053,37	
A.VIII	VIII. Total income tax	037	96 760,00		96 760,00	
A.VIII.29	29. Income tax	038	96 760,00		96 760,00	
	Total expenses	039	95 261 621,69	3 450 873,00	98 712 494,69	
B	B. Revenues					
B.I	I. Total operating grants	041	76 640 727,00		76 640 727,00	
B.I.1	1. Operating grants	042	76 640 727,00		76 640 727,00	
B.III	III. Revenues of own services and merchandise	047	467 731,27	3 987 479,45	4 455 210,72	
B.IV	IV. Total other revenues	048	18 676 076,64		18 676 076,64	
B.IV.5	5. Contractual fines, delay interests, other fines and penalties	049	28 000,00		28 000,00	
B.IV.7	7. Interest income	051	4 029,83		4 029,83	
B.IV.8	8. Exchange rate gains	052	3 008,73		3 008,73	
B.IV.9	9. Settlement of funds	053	936 298,10		936 298,10	
B.IV.10	10. Other revenues	054	17 704 739,98		17 704 739,98	
B.V	V. Total revenues from assets sold	055	27 188,93		27 188,93	
B.V.13	13. Revenues from disposals of materials	058	27 188,93		27 188,93	
	Total revenues	061	95 811 723,84	3 987 479,45	99 799 203,29	
C	C. Profit / Loss before tax	062	646 862,15	536 606,45	1 183 468,60	
D	D. Profit / Loss after tax	063	550 102,15	536 606,45	1 086 708,60	