

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



ANNUAL REPORT 2023

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This english translation serves for informative purposes only, legally binding is the Czech version.

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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 of the CAS) and the activities there of

Composition of the Institute's statutory bodies

Director:	RNDr. Filip Hartvich, Ph.D.			
Board of the Institute:				
Chairman:	RNDr. Josef Stemberk, CSc.			
Vice-chairman:	Mgr. Martina Havelcová, Ph.D.			
Internal members:	Ing. Olga Bičáková, Ph.D., Mgr. Jan Blahůt, Ph.D., RNDr. Jiří Málek, Ph.D., doc. Ing. Tomáš Suchý, Ph.D. RNDr. Petra Štěpančíková, Ph.D.			
External members:	Mgr. Jiří Adamovič, CSc., (Geological Institute of the CAS), Prof. RNDr. Tomáš Fischer, Ph.D. (Charles University Prague, Faculty of Natural Sciences), doc. Ing. Jaroslav Kloužek, CSc. (University of Chemistry and Technology Prague) Ing. Pavel Kriegsman, (KM, s.r.o.),			
Secretary to the Board:	doc. RNDr. Pavel Straka, DrSc.			
Supervisory Board:				
Chairman:	RNDr. Pavel Krejčí, CSc. (Institute of Mathematics of the CAS)			
Vice-chairman:	Mgr. Lucia Fojtíková, Ph.D. (Institute of Rock Structure and Mechanics of the CAS)			
Members:	doc. Ing. Jakub Kostelecký, Ph.D. (Faculty of Civil Engineering CTU in Prague) prof. RNDr. Jakub Langhammer, Ph.D. (Charles University Prague, Faculty of Natural Sciences) Ing. Radek Sedláček, Ph.D., (Faculty of Mechanical Engineering CTU in Prague),			
Secretary to the Board:	RNDr. Jakub Stemberk, Ph.D.			

Activities of the Institute's statutory bodies

Director:

- Director issued a total of 8 organisational communications during 2023. Meetings were held on a monthly basis between the Institute's management and heads of department.

- Contracts were concluded for new Czech Science Foundation (GA CR) projects.

- The publication activities of the Institute's researchers were assessed in the form of a competition and the results subsequently published and granted financial awards.

- Members of the Academy of Science executives headed by the President of the CAS prof. Eva Zažímalová visited the institute in November, as part of the visit there were presentations of most important results of the institute's individual departments and meetings with department heads and the institute's management.

- The Supervisory Board and the Board of the Institute approved the intention of the IRSM to take over the Department of Physical Properties of Rocks of the Geological Institute of the CAS, as new laboratory and department from 1 January 2024. Dr. Blahůt was appointed as the new Head of the Department.

- Reconstruction work of the new areas of Department of Neotectonics and Thermochronology in building C and the roof of building F (preparation for the PVP plant).

- The project, documents and the application for the construction procedure have been acquired and construction work has started for the implementation of the photovoltaic power (PVP) plant on the roofs of institute buildings of the IRSM and MIA CAS, which is planned for 2024.

Board of the Institute:

The Board of the Institute held four regularly-scheduled meetings during 2023: 27 February, 1 June, 28 November and 14 December.

- 27 February - The institute's financial statements of the 2022 and the budget for 2023 were discussed and approved, the activities related to the submission of research project proposals to the Czech Science Foundation (GA ČR) and the status of the transfer of the laboratory of new department in Pushkin Square Prague 6 of the Institute of Geology of the CAS to the IRSM of the CAS were discussed.

- 1 June - The Annual Report of the IRSM for 2022 was approved. In addition, 19 research project proposals were approved for submission to the Czech Science Foundation (GA ČR) and organisational arrangement related to the IRSM library and the transfer of the aforementioned new Department in Pushkin Square Prague 6 were discussed.

- 28 November - The Board approved the transfer of the institute's financial activities results in 2022 to the Reserve Fund. The Director of the institute submitted the transfer of the new Department and the related changes to the institutional Organizational chart to the Institution's Council for approval. The new department will be named the Department of Applied Rock Mechanics and will become a part of the Institute as of 1 January 2024. Its headquarters will be located at Pushkin Square Prague 6 - Dejvice. Dr. Jan Blahůt will be appointed as the Head of the Department.

- 14 December - The economic activity of the Institute in 2023 was discussed. The Institute operated in 2023 with due care and showed a positive economic result. The economic outlook for

2024 was discussed, amendments and additions to the Staff Regulations of the Institute after the application of the amendment to the Labour Code and a new wage regulation of the Institute was approved, effective from 1 January 2024. Furthermore, the payment of the retention fee to Stavba Praha družstvo from the Reserve Fund was approved.

Supervisory Board:

In accordance with the Rules of Procedure, the Supervisory Board met twice in 2022, and discussed of 4 total issue via letter. The Board was provided with the institute's financial activities results, its 2022 Annual Report and the budget for 2023.

The first meeting of the Board, held on 30 May 2023, included the verification and approval of the of the last February meeting, a discussion on the disbursement of the IRSM budget in 2022 and the outlook for 2023, and a discussion on, and the noting of, the financial and auditor's reports for 2022. Further, the Board discussed and approved the Report on the Activities of the IRSM Supervisory Board for 2022 and The Annual Report of the IRSM for 2022. The activities and results of the IRSM were discussed and the Board was informed of organisational changes and scientific and management issues. A draft assessment of the director of the IRSM was discussed and subsequently approved. Results of postal votes no. 1/2023 were approved.

At its second meeting, which took place on 13 December 2023, the Board verified and approved the minutes of the January 2022 meeting no. 1/2023 and postal votes no. 2/2023, 3/2023, 4/2022. The Board also discussed the disbursement of the budget in 2023 and the outlook for 2023. The Board was informed by the Director of transfer of Department of Physical Properties of Rocks of the Institute of Geology of the CAS to the IRSM next year as part of the Department of Engineering Geology. The Board was also informed about the intention of building a photovoltaic power plant on the roofs of the institutional buildings. Dr. Pavel Krejčí ended as Chairman of the Supervisory Board on 31 December 2023. The members of the Supervisory Board thanked him for his previous chairmanship.

During 2023, the Board discussed and approved 4 draft resolutions by letter with concern

to:

- lease agreement for business premises between the IRSM of the CAS and S PRO ALFA CZ, represented by Mr. Ivan Kadeřávek and Mr. Milan Waldstein and lease agreement for business premises between the IRSM of the CAS and the Academy of Fine Arts in Prague, represented by PhDr. Evžen Mrázek (lessee).
- 2) two donation contracts between the IRSM of the CAS and the IG of the CAS.
- 3) apartment lease agreement between the IRSM of the CAS and Dr. Chandreyee Goswami.
- 4) conclusion of the contract for the ACONTIP, s.r.o company as the financial auditors of the IRSM for 2023

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 both research in selected geoscientific fields and the socially desirable research of materials.

- Geoscientific research:

The study of the properties of rocks employing instrumental methods and the research of rocks focusing on the conditions for the emergence of natural and induced geodynamic processes and activities in the upper layer of the earth's crust, namely:

- processes that threaten the stability of the earth's surface and the minimisation of their adverse impacts;

- the monitoring and study of the propagation of seismic waves in various rock environments;

- the monitoring and analysis of slope and tectonic movements;
- the study of the paleo-stress conditions in the Czech massif;

- the study of neo tectonic phenomena in the USA and Turkey.

- Materials research:

The study of raw materials and organic and inorganic materials focusing on their origin and properties and with regard to their use in the medical, glassmaking, construction and environmental technology sectors, namely:

- the preparation and research of the properties of collagen materials for use in the field of vascular surgery, the modelling of smelting processes, the development of new smelting facilities and the vitrification of radioactive waste;

- the preparation of special glass materials that are permeable to infrared radiation and the characterisation thereof;

- the development of hybrid composites with reinforcement for lightweight roofing purposes;

- the preparation of new geopolymer composites aimed at reducing the ecological burden;

- the development of technologies for the heat treatment of sludges, biomass and plastic waste.

The Institute achieved a number of significant research results during the year via international cooperation, especially with foreign research institutions, cooperation with domestic research facilities, universities and other institutes of the Academy of Sciences of the Czech Republic and cooperation with industrial organisations Road and Motorway Directorate of Czech Republic, Energoprůzkum Praha, Czech Radioactive Waste Repository Authority (SÚRAO), The Vyšehrad National Cultural Monument, a contributory organisation of the City of Prague, Adršpach, s.r.o. technical services, etc.).

One outcomes are described below as example of successful international cooperation:

1) Paleoseismology of a Major Crustal Seismogenic Source Near Mexico City: The Southern Border of the Acambay Graben.

Summary:

The result of a paleoseismic survey in the Acambay Basin in central Mexico on the Venta de Bravo fault revealed two large Holocene earthquakes and a slip rate of 0.1 to 0.23 mm/yr. The seismic hazard resulting from the data was evaluated and compared with activity on nearby faults in the basin. The maximum magnitude of a possible future earthquake was estimated to be Mw = 7.

The result was achieved in collaboration with Universidad Nacional Autónoma de México; Universitat de Barcelona; Departamento de Geología, Baja California, México; Sapienza University of Rome; Université Grenoble Alpes.

Publication:

Leon-Loya R., Lacan P., Ortuno M., Zuniga R.F., Štěpančíková P., Stemberk Jakub, Hernández Flores A.P., Carrera Hernández J.J., Sunye-Puchol I., Aguirre-Díaz G.J., Audin L.: Paleoseismology of a Major Crustal Seismogenic Source Near Mexico City: The Southern Border of the Acambay Graben. Tectonics 2023, 42(6), e2022TC007610, doi:10.1029/2022TC007610

Illustration:



The figure shows the progress of the Venta de Bravo fault on an aerial photograph and deformation on the fault in an exploratory palaeoseismic trench.

A: Aerial photograph of the Canchesdá site along the Venta de Bravo Fault (VBF), red rectangles indicate the location of trenches.

B: Oblique aerial view showing the trace and the two splays of the VBF at the Canchesdá site (derived from Google Earth).

C: Picture of the scarp showing the location of Canchesdá-1 and Canchesdá-2 trenches.

D: Fault plane within a second order tributary of the Lerma River.

E: Detail of striated fault plane.

F: Exploratory trench Canchesdá-4 excavated to the east of Can-creek exposure.

As an example of **cooperation with universities and institutes of the Czech Academy of Sciences**, we present the following result:

2) Evolution of palaeoclimate, palaeoenvironment and vegetation in Central Europe during the Miocene Climate Optimum.

Summary:

The studied parastratotype profile of the regional Carpathian foreland (late Burdigalien) in the Hevlín quarry indicates the existence of a warm-temperate to subtropical palaeoclimate with a zonal vegetation cover of subtropical deciduous evergreen forest and warm-temperate to subtropical mixed mesophytic forest. These findings are consistent with global trends (high temperatures and high sea level) and suggest the occurrence of relatively widespread wet conditions during the Miocene climatic optimum.

The result was achieved in collaboration with the Faculty of Science of Charles University Prague, the Faculty of Science of Masaryk University Brno, the University of Bonn and Geological Institute of the CAS.

Publication:

F. Scheiner, M. Havelcová, K. Holcová, N. Doláková, S. Nehyba, L. Ackerman, J. Trubač, Š. Hladilová, J. Rejšek, T. Utescher, 2023: Evolution of palaeoclimate, palaeoenvironment and vegetation in Central Europe during the Miocene Climate Optimum. *Palaeogeography, Palaeoclimatology, Palaeoecology* 611, 111364, doi.org/10.1016/j.palaeo.2022.111364

Illustration:



Fig. A schematic simplified model of the reconstructed palaeoenvironment at the Hevlín locality. Positions of the analysed sections within the depositional system are indicated by white columns.

As an example of **applied research**, we present the following result:

3) Geopolymer-based grinding stones utilizable in metal machining.

Summary:

A clay-slag geopolymer with corundum grains was first time used to prepare novel abrasive tools for metal grinding. The results have proven that, in case of metal grinding, a geopolymer matrix can substitute for ceramic binder in grinding tools. The geopolymer grinding stones are an opportunity to sustainable development of a new generation of abrasive materials which utilize waste materials, save primary raw material resources and energy consumption and has a minimum impact on the environment.

The result was achieved in cooperation with the industrial company I&AAT s.r.o., Bustehrad - Kladno.

Publication:

Perná I., Hanzlíček T., Lučaník A., Šupová M. (2023): Geopolymer-based grinding stones utilizable in metal machining. *Construction and Building Materials* 363, 129869. doi: 10.1016/j.conbuildmat.2022.129869

Illustration:



Fig. General view of a ground seam steel tube.

For an example of the **use of research results in practice**, we present the following result:

4) The electron beam irradiation of collagen in the dry and gel states: The effect of the dose and water content from the primary to the quaternary levels.

Summary:

The aim was to describe the impact of collagen in the gel and dry state to various doses of electron beam radiation (1, 10 and 25 kGy) which are using for food processing and sterilization Irradiation of collagen in different states has different effects: irradiation in the dry state mainly causes the breakdown of collagen molecules; irradiation of the gel with increasing doses causes a change in its mechanical properties, in particular an increase in its elastic modulus. Irradiation increases the cross-linking of scleroprotein molecules (with only partial degradation), but does not alter the composition and morphology of collagen, either in the gel or in the dry state.

The result was achieved in collaboration with the Faculty of Mechanical Engineering of the Czech Technical University in Prague, the Food Research Institute Prague, Nuclear Physics Institute CAS Řež and University of Chemistry and Technology Prague

Publication:

M. Šupová, T. Suchý, H. Chlup, M. Šulc, T. Kotrč, L. Šilingová, M. Žaloudková, Š. Rýglová, M. Braun, D. Chvátil, Z. Hrdlička, M. Houška (2023): The electron beam irradiation of collagen in the dry and gel states: The effect of the dose and water content from the primary to the quaternary levels. *International Journal of Biological Macromolecules* 253 (2023) 126898. doi.org/10.1016/j.ijbiomac.2023.126898

Illustration:



Fig. Representative SEM images of the collagen gel before irradiation (0 kGy) and the collagen gels irradiated with doses of 1, 10 and 25 kGy. The images in the left column were taken at a magnification of 20,000× (the bar represents 5 μ m), and those in the right column at a magnification of 50,000× (the bar represents 2 μ m).

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

The Institute conducted its scientific activities during the year via all six of its research departments, four of which focused on geoscientific and two on materials disciplines: Geoscientific research was conducted by the Departments of Engineering Geology, Department of Neotectonics and Thermochronology, Department of Seismotectonics and Department of Geochemistry.

Materials research was performed by the **Department of Composite and Carbon materials** and the **Department of Material Structure and Properties**.

The institute's scientific departments benefit from the sharing of research facilities with various universities. Laboratory of Sorption and Porosimetric Analyse of institute's Geochemistry Department is joint laboratory established by the Institute of Rock Structure and Mechanics together with the Faculty of Science, Charles University. Similarly, the Department of Material Structure and Properties Materials' Inorganic Materials Laboratory is shared with the University of Chemical Technology, Prague.

In 2023, the Institute's scientific departments were involved in the Strategy AV21 research programmes, in 4 international projects, cooperated with domestic and numerous foreign universities and research centres, and carried out contracts for practice. The staff of the Institute took part in important international scientific committees, organised two scientific conferences and participated in the popularisation of science and public education. Dr Jan Klimeš received the major international prize "Hiroshi Fukuoka Award" (awarded by the International Consortium on Landslides, Florence 2023) for his research on landslides and ways to reduce their risk in Peru. The Institute has been awarded 2 patents, one of them European, and a one utility model.

The staff of the Institute's scientific departments continued to be involved in teaching at various universities in 2023, not only at Czech universities, but also at Oregon State University, Corvallis, USA and Universidad Nacional de Cordóba, Argentina.

<u>The Department of Engineering Geology</u> focuses on the analysis and interpretation of dangerous geodynamic phenomena associated with exogenous processes, i.e. slope deformations and weathering. Particular attention was devoted during the year to the development of reliable and accurate monitoring methods for the monitoring of slope phenomena, especially landslides, and the prediction of their future occurrence and development.

The department was involved in international research on slope deformations and tectonic structures via the use of the following **monitoring networks**:

- Name of network: **TecNet**

Monitored issue: Microdisplacements on tectonic faults. Operator: IRSM + cooperating organisations RI/OP VVV Programme Content: Tracking of seismic tectonic movements along faults.

Name of network: Geonas
Monitored issue: GNSS fixed point movements.
Operator: IRSM
RI/OP VVV Programme
Content: Monitoring of tectonic movements.

- Name of network: **SlopeNet** Monitored issue: Slope processes / landslides, rockfalls. Operator: IRSM RENS Programme Content: Monitoring of slope movements and rockfalls.

- Name: Landslides, rockfalls and debris flows described in the media since 2011 Monitored issue: Initiation and reactivation of slope deformations in the Czech Republic. Operator: IRSM NASA Programme Content: To determine the location and time of the occurrence of landslides and the damage they cause.

Main outcomes:

1) Rock Surface Strain In Situ Monitoring Affected by Temperature Changes at the Požáry Field Lab (Czechia).

Summary:

A resistive strain gauge method for quantifying rock outcrop surface deformation directly in the field has been verified. An experiment was carried out to apply low cost resistive strain gauges directly to the rock surface. Continuous measurements were then taken over a period of approximately 6 months. The data was then analysed to determine the effect of temperature on the performance of different types of strain gage connection. A high, even theoretical, accuracy of the method was found, but also the need to process the results taking into account the significant influence of temperature on the measurement outputs.

Publication:

Racek O., Balek J., Loche M., Vích D., Blahůt J. (2023): Rock Surface Strain In Situ Monitoring Affected by Temperature Changes at the Požáry Field Lab (Czechia). *Sensors* 23(4): 2237. doi.org/10.3390/s23042237

Illustration:



Fig. Sketch of strain gauge configurations. The figure shows the location of the instruments and the detection of both intact rock and microcrack. The configurations of instruments are presented with their different shapes and orientations (red and blue color) for testing possible distinct behavior under temperature changes.

2) New Insights into the Internal Structures and Geotechnical Rock Properties of the Giant San Andrés Landslide, El Hierro Island, Spain.

Summary:

The San Andrés landslide on El Hierro (Canary Islands) represents a rare opportunity to study an incipient volcanic island flank collapse with an extensive onshore part. The presented research improves the knowledge of the internal structure and rock characteristics of a megalandslide before its complete failure. The onshore geophysical investigations helped detect the possible San Andrés landslide sliding surfaces at depths between 320 m and 420 m, with a rather planar geometry and they also revealed that rocks inside and outside of the landslide had similar properties which suggests that the previous fast movements of the landslide did not affect the bulk properties of the displaced rocks.

Publication:

Klimeš J., Hussain Y., Mreyen A.-S. Cauchie L., Schlögel R., Piroton V., Petružálek, M., Blahůt J., René M., Meletlidis S., Havenith H.-B. (2023): New Insights into the Internal Structures and Geotechnical Rock Properties of the Giant San Andrés Landslide, El Hierro Island, Spain. *Remote Sensing* 15, 1627. doi:10.3390/rs15061627

Illustration:



Fig. 3D geomodel of the studied El Hierro. (a) The central part of the SAL with inserted geological cross-section and geophysical results with the detailed view in the inset (b); (c) view of the SW part of the San Andrés landslide with the results of the geophysical measurements and detailed view in the inset (d).

Further outcomes:

 Šilhán K., Fabiánová A., Klimeš, J., Tábořík, P., Hartvich, F., Blahůt, J. (2023): The effect of tree growth disturbances inertia on dendrogeomorphic spatio-temporal analysis of landslides: A case study. *CATENA* 235, 107678.
doi.org/10.1016/j.catena.2023.107678

- Šilhán K., Balek J., Hartvich F., Klimeš J., Blahůt J., Hampel F. (2023): Anatomical growth response of *Fagus sylvatica* L. to landslide movements. *Science of the Total Environment* 867, 161554. doi.org/10.1016/j.scitotenv.2023.161554

- Duque J., Loche M., Scaringi, G. (2023): Rate-dependency of residual shear strength of soils: implications for landslide evolution. *Géotechnique Letters* 13(2),1–8. doi.org/10.1680/jgele.23.00004

- Mitrovic-Woodell I., Tesei T., Plan L., Habler G., Baroň I., Grasemann B. (2023): Deformation of columnar calcite within flowstone speleothem. *Journal of Structural Geology* 174, 16 pp., 104924. <u>doi.org/10.1016/j.jsg.2023.104924</u>

- Racek O., Balek J., Loche M., Vích D., Blahůt J. (2023): Rock Surface Strain In Situ Monitoring Affected by Temperature Changes at the Požáry Field Lab (Czechia). *Sensors* 23(4): 2237. doi.org/10.3390/s23042237

- Raška P., Riezner J., Bíl M., Klimeš J. (2023): Long-term landslide impacts and adaptive responses in rural communities: Using historical cases to validate the cumulative causation approach. International *Journal of Disaster Risk Reduction* 93, 103748. doi.org/10.1016/j.ijdrr.2023.103748

- Rowberry M., Trčka T., Mikluš V. (2023): Portable muon detectors tested at the British Cave Science Centre. *Cave and Karst Science* 50 (3), 113–118.

- Tong Z. L., Guan Q. T., Arabameri A., Loche M., Scaringi G. (2023). Application of novel ensemble models to improve landslide susceptibility mapping reliability. *Bulletin of Engineering Geology and the Environment* 82(8), 309. doi.org/10.1007/s10064-023-03328-8

The Department of Neotectonics and Thermochronology in 2023 addressed neo-tectonic and geodynamic processes in various tectonic regions and paleo-stress conditions in the Bohemian Massif, including the monitoring of fault structures: the marginal Sudeten, Marianske Lazne, Čirá-Kopanina and Lusatian (Lužický) faults. Foreign tectonic and geophysical research was conducted in US in the San Andreas fault zone and reconnaissance of the extensional region around Izmir region, Turkey to select sites for monitoring fault movements and field research and sampling focused on thermochronological evolution of areas at the lithospheric plate interface. In cooperation with other geoscience institutions, the department participated in research on slope deformations and the structural-tectonic development of sandstone reliefs in the Czech Republic and Poland as well as using geophysical methods in interdisciplinary studies.

The department was involved in international research on slope deformations and tectonic structures via the use of the following monitoring networks:

- Name of network: **SlopeNet**

Monitored issue: The monitoring of slope deformations, landslides and rockfalls. Operator: IRSM

RENS Programme

Content: The geophysical and geotechnical monitoring of slope deformations, active involvement in international research and the taking over of co-responsibility for monitoring.

Name of network: Network EU TecNet
Monitored issue: Tectonic structures in the EU.
Operator: IRSM
Czech/Geo Programme.
Content: active involvement in the EU network, meter reading and service, and data evaluation.
Main outcomes:

1) First paleoseismic data from the Balkan Range

Summary:

The strike-slip faults form a basin-and-range relief in the Balkan Mountains with low historical seismicity and extension rates. A paleoseismic survey was carried out on the Zlatitsa fault, which revealed two major earthquakes in 42,000 years. These earthquakes are similar to the M 6.8-7.1 cluster on the adjacent faults in 1904 and 1928. The geodetic rate on the eastern faults is consistent with the detected paleoseismic rate. This may indicate that while the Zlatitsa fault is in a stress recovery phase, the adjacent faults may already be close to collapse.

Publication:

Radulov A., Dilov T., Rockwell T., Štěpančíková P., Yaneva M., Donkova Y., Stemberk J., Sana H., Nikolov N. (2023): First paleoseismic data from the Balkan Range. *Tectonophysics* 863, 230009. <u>doi.org/10.1016/j.tecto.2023.230009</u>

Illustration:



Fig. Geological profile of the exploratory trench across the Zlatitsa fault. Geological profile of the exploratory trench across the Zlatitsa fault, showing faults and boundaries of two identified earthquakes of the last 40 thousand years. Trench log. Calibrated radiocarbon ages are shown by medians.

2) New developments in onshore paleoseismic methods, and their impact on Quaternary tectonic studies.

Summary:

This outcome describes the new technologies and interpretations that arose over the past decade. The major technological advances have been in remote sending, e.g., unpiloted aerial vehicles (drones); airborne laser scanning (lidar); terrestrial laser scanning; 3D topographic surveys from Structure-from-Motion; and satellite geodesy such as D-InSAR. Advances have also been made in dating Quaternary deposits, including single-grain luminescence dating (in the laboratory), and portable optically-stimulated luminescence dating (in the field). Geophysical surveys are now a common component of neotectonic investigations, permitting

a more formal, 3D integration of subsurface data with surface data. These techniques have lowered the threshold of recognition to smaller and smaller earthquakes, and allowed detection of off-fault deformation such as distributed faulting and folding.

Publication:

McCalpin J., Ferrario F., Figueiredo P., Livio F., Grützner C., Pisarska-Jamroży M., Quigley M., Reicherter K., Rockwell T., Štěpančíková P., Tábořík P. (2023): New developments in onshore paleoseismic methods, and their impact on Quaternary tectonic studies. *Quaternary International* 664, 59-76.

doi.10.1016/j.quaint.2023.03.008

Illustration:



Fig. Investigation of the Mariánské Lázně Fault (MLF) in Czechia. (Left) Shallow detailed survey focused on a trenching site: (A) a detailed ERT (top) and GPR (bottom) sections with simplified geological log overlaid; (B) 2D ERT combined with 3D GPR (pseudo 3D view) - mutual correlation of high reflective (GPR) and high resistive (ERT) sedimentary bodies; (C) 3D GPR depth (time) slices - a reconstruction of the pre-faulting state points out on a dextral strike-slip on younger faults intersecting the sedimentary bodies. (Right) Deep large-scale

survey of MLF: (D) SSR - P-wave seismic velocity model; (E, F) gravity survey - (E) a curve of the Bouguer anomalies, (F) a forward gravity model derived from the Bouguer anomalies; (G) ERT - an inverse resistivity model with a topography with interpreted main geological units; (G) AMT - an audiomagnetotelluric survey inverse section showing the situation to the depth of 1 km.Further outcomes:

See pages 6 and 7 for other significant outputs of the Department.

Further outcomes:

- Duffek V., Tábořík P., Stacke V., Mentlík P. (2023): Origin of block accumulations based on the near-surface geophysics. *Open Geosciences* 15(1), 20220468. <u>doi.org/10.1515/geo-2022-0468</u>

- Flašar J., Martínek K., Verner K., Kalinová R. (2023): Neogene-Quaternary response of the Novohradské hory Mts. (Czech Republic) fluvial systems to tectonics – Analyses of morphotectonics, stream-length index and structural geology. *Quaternary International* 656, 1–15. doi.org/10.1016/j.quaint.2023.01.008

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- Sana H., Ullah R., Zinke R., Fielding E. (2023): Torkham Rockslide of April 18, 2023, in Pakistan: an interplay of geomorphology, geology, slope cutting, and climate. *Landslides* 21, 223–228. <u>doi.org/10.1007/s10346-023-02164-x</u>

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<u>The Department of Seismotectonics</u> addressed the study of natural seismic phenomena associated with the dynamics and tectonic development of structures in the earth's crust (especially in the upper part of the crust), the development of applications for the evaluation of geophysical measurements, and the development of monitoring devices and methodologies for seismic activity research purposes. The department continued its assessment of seismic hazards affecting nuclear power plants.

The department was involved in international research on seismic phenomena via the following monitoring networks:

- Name of network: Czech Regional Seismic Network.

Monitored issue: Earthquakes in the Czech Republic and worldwide.

Operators: Czech Academy of Sciences (CAS): Institute of Geophysics, IRSM, Institute of Geonics; Institute of Physics of the Earth of Masaryk university; Institute of Geodesy, Topography and Cartography Zdiby, Faculty of Mathematics and Physics Charles University Prague, Observatory Úpice, Military Geographic and Hydrometeorologic Office (VGHMÚ) Dobruška, German Research Center for Geosciences - GEOFON Potsdam, Zentralanstalt für Meteorologie und Geodynamik (ZAMG) Viena, Technical university of Ostrava Czech/Geo Programme

Content: Basic scientific infrastructure for the research of earthquakes, especially concerning long-term seismicity research in Europe and worldwide.

- Name of network: **REYKJANET**

Monitored issue: Earthquakes in Iceland

Operators: Institute of Geophysics and Institute of Rock Structure and Mechanics of the CAS Czech/Geo Programme

Content: The detailed long-term international research of the seismic activity in Iceland.

- Name of network: MKNET

Monitored issue: Earthquakes in the Lesser Carpathians.

Operators: IRSM; Institute of Geophysics, Earth Science Institute of the Slovak Academy of Sciences and Progseis s.r.o.

Czech/Geo Programme

Content: Detailed research of this seismically active area; continuous recording and evaluation of the data.

- Name of network: WEBNET

Monitored issue: Earthquake in western Bohemia.

Operators: Institute of Geophysics and Institute of Rock Structure and Mechanics of the CAS Czech/Geo Programme

Content: Detailed long-term study of seismically active area in western Bohemia

Main outcomes:

1) MASW? A critical perspective on problems and opportunities in surface-wave analysis from active and passive data (with few legal considerations).

Summary:

The difference between the standard MASW (Multichannel Analysis of Surface Waves) approach, based on data obtained from a set of vertical geophones, and the analysis of data obtained from a single three-component (3 C) geophone has been demonstrated to provide more information and thus enable reliable shear-wave velocity profiles (VS profiles) to be efficiently obtained. This is possible because surface-wave analysis can be effectively carried out considering not phase velocities but group velocities, with the obvious benefit that while for

the phase-velocity analysis multi-offset data are necessary, the definition of the group velocities can be accomplished from single-offset data (i.e. from the data of one single sensor).

Publication:

Dal Moro G. (2023): MASW? A critical perspective on problems and opportunities in surfacewave analysis from active and passive data (with few legal considerations), *Physics and Chemistry of the Earth* 130, 103369. doi:10.1016/j.pce.2023.103369

Illustration:



Fig. Field image from a palaeoseismological survey. The eroded bank where the simple site stratigraphy is clearly exposed: a soft-silt sequence lies over a series of gravel layers (mud-gravel contact).

2) Seismic Beacon - A New Instrument for Detection of Changes in Rock Massif.

Summary:

The seismic beacon is a new instrument that allows for the measurement of changes in a rock massif with high sensitivity. It is based on effects, which affect the propagation of harmonic seismic waves generated continuously with stable and precise frequency and amplitude. The seismic beacon has been developed primarily for the detection of critical stress before an earthquake, which is manifested by non-linear effects such as higher harmonics generation. In addition, it could be used, for example, in the detection of magma movements, groundwater level changes, changes in hydrocarbon saturation in rocks during the extraction of oil and natural gas, or the penetration of gases and liquids into the earth's crust.

Publication:

Lukešová R., Málek J. (2023): Seismic Beacon – A New Instrument for Detection of Changes in Rock Massif. *Sensors* 24, 234. doi.org/10.3390/s24010234

Illustration:



Fig. Diagram of a harmonic seismic wave generator. The figure displays side sections of the well. A rotor with two rolling elements (light grey frustums) moves around the vertical axis along a path at the bottom of the well (black thick line). The rotation is driven by a motor (black rectangle). The well is evacuated by a compressor (grey rectangle) in the top of the well and the temperature is held constant using a heater (black dots) and thermometers (white dots).

3) Induced Microseismic Event with Strong Rupture Directivity and Superimposed Attenuation Effects.

Summary:

During hydraulic fracturing of a shale reservoir in China, fracture directivity for an induced microseismic event of Mw~1.2 recorded by a dense surface star network of seismometers was determined For this purpose, We use the duration of the initial P-wave arrivals as a proxy for the peak frequency content The observed directional and offset dependence of the peak frequencies can be explained by superposed directionality effects of fast, possibly superstrong, fracture propagation and attenuation, allowing the orientation of the fracture plane of the event to be determined.

Publication:

Wcislo M., Staněk F., Gallovič F., Wu S., Pšenčík I. (2023): Induced Microseismic Event with Strong Rupture Directivity and Superimposed Attenuation Effects. Seismological Research Letters 94, 1455–1466. doi.org/10.1785/0220220229

Illustration:



Fig. Induced microseismic effect of Mw~1.2, crack directivity: a) logarithms of observed peak frequencies, color scale corresponds to the range with 5% cut-off of highest/lowest values (3.51)/(4.20); b-c) logarithms of peak frequencies for the best-fit models of two different scenarios, considering (b) attenuation only (c) attenuation and directivity. The black star indicates the epicentre of the earthquake.

Further outcomes:

- Dal Moro G. (2023), book: Lezioni di sismica (Onde di volume, di superficie, sezioni 2D e amplificazioni), *Dario Flaccovio Editore*, <u>ISBN 9788857911946</u>.

- Málek J., Brokešová J., Novotný O. (2023): New Velocity Structure of the Nový Kostel Earthquake-Swarm Region, West Bohemia, Determined by the Isometric Inversion. *Pure and Applied Geophysics* 180(6):1–24. doi:10.1007/s00024-023-03250-w

- Mazanec, M., and J. Valenta (2023): Surface Waves as a Cost-Effective tool for Enhancing the Interpretation of Shallow Refraction Seismic Data. *Acta Geodynamica et Geomaterialia* 20, 3(211), 121–138. doi:10.13168/AGG.2023.0012.

- Fischer T., Vlček J., Dědeček P., Řihošek J., Zimmermann G., Holeček J., Mazanec M., Rukavičková L., Janků L., Káldy E. (2023): Hydraulic injection tests in the pilot EGS borehole PVGT-LT1 in Litoměřice, Czechia. *Geothermics* 115, 102805. doi:10.1016/j.geothermics.2023.102805

- Matyska C., Zábranová E. (2023): Heat extraction calculations for deep coaxial borehole heat exchangers: matrix analytical approach. *Geophysical Journal International* 235, 2323–2338. doi:10.1093/gji/ggad367

The Department of Geochemistry focused on the study of organically rich materials, in which systematic characterization of fossil samples, identification of biological resources, reconstruction of accumulation conditions, charring, maturation and weathering in sedimentary environments. Geochemical approaches are also used in the study of non-geological problems, for example in the long-term study of the relationship between resins of modern and fossil conifers. Furthermore, the properties of waste materials as sorbents and the properties of natural and synthesized carbonaceous materials as filters and contaminants associated with coal mining. Following to research in previous years, granitic rocks, tektites, foams and uranium ores and the interaction of uranium minerals with organic matter.

Main outcomes:

1) Evolution of palaeoclimate, palaeoenvironment and vegetation in Central Europe during the Miocene Climate Optimum.

For details of this output, see page 8.

Further outcomes:

- Klimeš J., Hussain Y., Mreyen A.S., Cauchie L., Schlögel R., Piroton V., Petružálek M., Blahůt J., René M., Meletlidis S., Havenith H.B. (2023): New insights into internal structures and geotechnical rock properties of the giant San Andrés landslide, El Hierro island, Spain. *Remote Sensing* 15, 1627, 1–22. doi.org/10.3390/rs15061627

- G. Sádovská, P. Honcová, J. Morávková, I. Jirka, M. Vorokhta, R. Pilař, J. Rathouský, D. Kaucký, E. Mikysková, P. Sazama (2023): The thermal stability of carbon materials in the air: Quantitative structural investigation of thermal stability of carbon materials in air. *Carbon* 206, 211–225. doi.org/10.1016/j.carbon.2023.02.042

- Strunga V., Sihelská K., Lorinčík J., Holá M., Krausová I., Goliáš V., Čurda M., Mizera J. (2023): Natural bitumen hosted uranium mineralization: stability of the radiogenic systém. *Journal of Radioanalytical and Nuclear Chemistry* 332, 1597–1606. doi.org/10.1007/s10967-022-08692-5

- Švábová M., Bičákova O., Vorokhta M. (2023): Biochar as an effective material for acetone sorption and the effect of surface area on the mechanism of sorption. *Journal of Environmental Management* 348, 119205. <u>doi.org/10.1016/j.jenvman.2023.119205</u>

- Vöröš D., Baizán P.D., Slavíček K., Díaz-Somoano M., Geršlová E. (2023): Mercury Occurrence and Speciation in Sediments from Hard Coal Mining in Czechia. *Journal of Hazardous Materials* 459,132204. doi.org/10.1016/j.jhazmat.2023.132204

- M. Vorokhta, M.I M. Kusdhany, D. Vöröš, M. Nishihara, K. Sasaki, S.M. Lyth (2023): Microporous carbon foams: The effect of nitrogen-doping on CO2 capture and separation via pressure swing adsorption. *Chemical Engineering Journal* 471, 144524. doi.org/10.1016/j.cej.2023.144524

- Karimi K., Kletetschka G., Mizera J., Meie V. (2023): Formation of Australasian tektites from gravity and magnetic indicators. Scientific Reports 13, 12868. doi.org/10.1007/s10967-022-08692-5

- Malhocká A., Švábová M. (2023): Diversity of the terpene synthesis in the Thuja species – a comparative chemotaxonomic study. *Biochemical systematics and ekology* 110, 104703. doi.org/10.1016/j.bse.2023.104703

- M. Vorokhta, J. Nováková, M. Dopita, I. Khalakhan, V. Kopecký Jr., M. Švábová, (2023): Activated three-dimensionally ordered micromesoporous carbons for CO2 capture. *Materials Today Sustainability* 24, 100509. doi.org/10.1016/j.mtsust.2023.100509

- Mizera, J., Krausová, I., Chvátil, D., Olšanský, V. (2023): Oxygen determination in the Ti certified reference material ERM-EB090b by instrumental photon activation analysis. *Journal of Radioanalytical and Nuclear Chemistry*. doi.org/10.1007/s10967-023-09260-1

- Malhocká A., Švábová M. (2023). A Chemotaxonomic Analysis of Terpenes Variation in Metasequoia glyptostroboides and Sequoiadendron giganteum resins. *Journal of Essential Oil Bearing Plants* 26, 1245–1255. doi.org/10.1080/0972060X.2023.2280139

- René M., Dolníček Z. (2023): Granitoids of the Mauthausen type in the Czech part of the Moldanubian Batholith. In: René M. (Ed.) Granite – Origin, Occurrence, Classification and Metallogeny. IntechOpen Ltd., London, 1–19.

- René M. (2023): Nb-Ta-Ti oxidy v topazových granitech cíno-wolframového rudní ložiska Ehrenfriedersdorf. *Zprávy o geologických výzkumech* 56, 1, 21–29.

- René M. (2023): Petrografie a geochemie amfibolitů strážovského moldanubika. *Bulletin Mineralogie Petrologie* 31, 1, 35–40.

<u>The Department of Composite and Carbon Materials</u> focused principally in the field of biomaterials on the study of the properties of collagen materials for medical and food applications, and on the description of the influence of the main structural components of the human aorta on its delamination properties. In the field of special composites, degradable magnesium materials were studied. The climatic resistance with partially pyrolysed polysiloxane matrix composites was characterized based on tests.

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The potential use of collagen in the form of degradable matrices was studied in a project aimed at the development of a resorbable arterial bandages based on a composite material composed of synthetic PCL/PLA copolymer nanofibre reinforcement and combined with collagen matrix for the purpose of reducing blood flow through the arterial circulation to protect arterial wall against pathological deformation and rupture (AZV MZČR NU20-02-00368).

In 2023, research activities were mainly focused on the description of the degradation behaviour of the developed composites under simulated body conditions and in vivo (rat model). In the framework of basic research on collagen materials, we have also been studying the physical chemical parameters of the collagen material, especially the effect of high pressures and monoenergetic accelerated electron beam on the internal structure of collagen gels with different concentrations (GAČR 21-07851S).

Research work has also focused on describing the influence of the main structural components of the human aorta on its delamination properties. This is material research dealing with the physical chemical and mechanical properties of biological tissues to answer questions related to the propagation of arterial tears and arterial rupture, conditions that clinically occurring in arterial dissection and rupture (GAČR 20-11186S).

Other work has focused on the development of technology for coating magnesium wires with degradable polymers, the development of degradable polymers used as surgical suture materials and the optimization of degradation time (TAČR GAMA 2 TP01010055 4GEO). The usability testing of degradable materials was performed in a simulated body environment.

The last area of biomaterials research in 2023 was the validation of the technology of collagen dispersion processing for impregnation of porous surfaces of anchoring parts of implants (TAČR GAMA 2, TP01010055 4GEO), in particular finding a suitable simulated body environment that corresponds most closely to real body conditions and its verification (degradation of structural and mechanical properties) in an *in vivo* model.

In the field of special composite materials, the main focus was on the problem of climate resistance of composites with partially pyrolyzed polysiloxane matrix reinforced with basalt fibres. In the framework of the TAČR GAMA 2, TP01010055 4GEO, a test rig and a method developed in the previous year for measuring the resistance to cyclic freezing were used. Long-term tests of repeated freezing cycles with periodic automatic wetting of the sample

were carried out to evaluate the change in mechanical properties compared to commercial fibre cement coverings.

Main outcomes:

1) The investigation of batch-to-batch variabilities in the composition of isolates from fish and mammalian species using different protocols.

Summary:

Procedures for processing and analysing collagen samples were evaluated and a study was carried out to provide a comprehensive description of the suitability of different methods of collagen isolation from a wide range of animal species and tissues in terms of reproducibility, quality and composition.

Publication:

Š. Rýglová, M. Braun, T. Suchý, M. Hříbal, M. Žaloudková, L. Vištějnová (2023): The investigation of batch-to-batch variabilities in the composition of isolates from fish and mammalian species using different protocols. *Food Research International* 169, 112798. doi.org/10.1016/j.foodres.2023.112798



Illustration:

Fig. Scheme of the sample processing and analysis procedure. FA, PA - fish and pig refers to isolates from process A and FB, PB from process B. FTIR - Fourier infrared spectroscopy, EDS - energy-dispersive spectrometer, SEM - scanning electron miscroscopy, SDS-PAGE - polyacrylamide gel electrophoresis. GAGs - glycosaminoglycans, AA - amino acids, Hyp - hydroxyproline.

2) Sandwich and composite collagen sponge for controlled release of active substances, and method of preparation thereof.

Summary:

The present invention relates to a method of preparation of a degradable sandwich collagen

sponge with hemostatic effects, controlled degradation time and capable of controlled local release of active substances, for example antibiotics for use in wound dressings in surgery, orthopedics, traumatology and plastic surgery, comprising a low porous collagen core and highly porous collagen sponge as peripheral parts.

Publication:

T. Grus, T. Suchý, M. Šupová, H. Chlup, J. Hartinger (2023): Sandwich and composite collagen sponge for controlled release of active substances, and method of preparation thereof. <u>EP 3 838 302</u>, European Patent Office, date of publication 23.08.2023.

Illustration:



Fig. Sandwich collagen foam: section with noticeably stiff, low-porosity core and high-porosity boundary layers.

Other significant results of department with details are presented on pages 9 and 10.

Further outcomes:

- C.M. Saratti, N. Scotti, A. Comba, J. Bijelic-Donova, T. Suchý, M. Abdelaziz, J.G. Leprince, G.T. Rocca (2023): Exploring the influence of placing bi-directional E-glass fibers as protective layer under a CAD-CAM resin composite on the fracture pattern. *Dental Materials* 39, 986–993. doi.org/10.1016/j.dental.2023.09.003

- I. Perná, T. Hanzlíček, A. Lučaník, M. Šupová (2023): Geopolymer-based grinding stones utilizable in metal machining. *Construction and Building Materials*, 363 129869. doi.org/10.1016/j.conbuildmat.2022.129869

- M. Šupová, T. Suchý, H. Chlup, J. Štípek, R. Žitný, A. Landfeld, J. Skočilas, M. Žaloudková, Š. Rýglová, M. Braun, J. Štancl, M. Houška (2023): The comprehensive evaluation of two

collagen gels used for sausage casing extrusion purposes: The role of the structural and mechanical properties *Journal of Food Engineering* 343, 111387. doi.org/10.1016/j.jfoodeng.2022.111387

- H. Chlup, T. Suchý, M. Šupová (2023): The electron beam induced cross-linking of bovine collagen gels with various concentrations: The mechanical properties and secondary structure, *Polymer* 287, 126423. <u>doi.org/10.1016/j.polymer.2023.126423</u>

- M. Houška, A. Landfeld, P. Novotná, J. Strohalm, M. Šupová, T. Suchý, H. Chlup, J. Skočilas, J. Štípek, M. Žaloudková, M. Šulc (2023): Properties of Bovine Collagen as Influenced by High-Pressure Processing. *Polymers* 15(11):2472. doi.org/10.3390/polym15112472

- E. Filova, M. Šupová, A. Eckhardt, M. Vrbacky, A. Blanquer, M. Trávničková, J. Knitlová, T. Suchý, S. Rýglová, M. Braun, Z. Burdíková, M. Schätz, V. Jenčová, M. Lisnenko, L. Behalek, R. Procházková, R. Sedláček, K. Kubasová, L. Bačáková (2023): Adipose-Derived Stem Cells in Reinforced Collagen Gel: A Comparison between Two Approaches to Differentiation towards Smooth Muscle Cells, International Journal of Molecular Sciences. 24(6) 5692. doi.org/10.3390/ijms24065692

- L. Bačáková, E. Filová, Š. Pražák, I. Vacková, T. Suchý, M. Šupová, J. Šepitka, R. Procházková, V. Jenčová, E. Kuželová Košťáková, M. Lisnenko, D. Lukáš, J. Valtera (2023): Reinforced composite hydrogel with cells. Užitný vzor č.: 37438.

<u>The Department of the Structure and Properties of Materials</u> continued the research of socially necessary technologies during the year: (a) Technological issues of glass production, the preparation of infrared-permeable glasses; the vitrification of radioactive waste for technical applications; (b) Preparation of new abrasive materials using geopolymer technology; (c) Processing of biomass and sewage sludge into useful products; (d) Low temperature catalytic pyrolysis of waste cross-linked polyethylene and polyactide waste acid, including 3D printing waste; (e) Separation of germanium from lignite for further use.

Main outcomes

1) Conversion degree and heat transfer in the cold cap and their effect on glass production rate in an electric melter.

Summary:

The predictive model of melt rate in waste glass vitrification operations is needed to inform melter operations during normal and off-normal operations. the development of a model of the cold cap describes that couples heat transfer with the feed to glass conversion kinetics. The model was applied to four melter feeds designed for high-level and low-activity nuclear waste feeds using the material properties, either measured or estimated, to obtain temperature and conversion distribution within the cold cap. The cold cap model, when coupled with a computational fluid dynamics model of a Joule-heated glass melter, allows the prediction of the glass production rate and power consumption. The results show reasonable agreement with the melting rates measured during pilot-scale melter tests.

Publication:

Ferkl P., Hrma P., Abboud A., Guillen D., Vernerová M., Kloužek J., Hall M., Kruger A.A., Pokorný R. (2023): Conversion degree and heat transfer in the cold cap and their effect on glass production rate in an electric melter. *International Journal of Applied Glass Science* 14, 318-329. doi: 10.1111/jiag.16615

	Electrodes Joule heating: 22.8 kW (100 %)	Feed conversion: 8.8 kW (39 %)	Dry feed conversion: 2.3 kW (10 %)		
			Water evaporation: 4.4 kW (19 %)		
waste glass			Evolved gases: 2.1 kW (9 %)		
melter: 22.8 kW (100 %)		In-leaked air: 7.1 kW (31 %)			
		Losses through walls: 6.9 kW (3	30 %)		

Illustration:

Fig. Energy balance of glass strain melting in a melting unit for radioactive waste vitrification.

Other significant result of department with details is presented on page 9.

Further outcomes:

- Khawand J., Kloužek J., Vernerová M., Cincibusová P., Hrma P., Kruger A., Pokorný R. (2023): Effect of sucrose on the oxidation-reduction conditions and retention of rhenium during vitrification of low-activity waste. *Journal of Nuclear Materials* 573, 154155. doi.org/10.1016/j.jnucmat.2022.154155

- Kolářová M., Kloužková A., Kohoutková M., Kloužek J., Dvořáková P. (2023): Degradation processes of medieval and renaissance glazed ceramics. *Materials* 16 (1), 375. <u>doi.org/10.3390/ma16010375</u>

- Rigby J.C., Dixon D.R., Kloužek J., Pokorný R., Thompson P.B.J., Scrimshire A., Kruger A.A., Bell A.M.T., Bingham P.A. (2023): Alternative reductants for foam control during vitrification of high-iron High Level Waste (HLW) feeds. *Journal of Non-Crystalline Solids* 608, 122240. doi.org/10.1016/j.jnoncrysol.2023.122240

- Ferkl P., Hrma P., Kloužek J., Kruger A., Pokorný R. (2023): Effect of material properties on batch-to-glass conversion kinetics. *International Journal of Applied Glass Science* 14, 491–501. doi.org/10.1111/ijag.16631

- Šponer J.E., Kloužek J., Výravský J., Wunnava S., Scheu B., Braun D., Mojzsis S.J., Palacký J., Vorlíčková M., Šponer J., Matyášek R., Kovařík A. (2023): Influence of Silicate Rock Glass Compositions on the Efficacy of Prebiotic RNA Polymerization Reactions: The Case of 3',5' Cyclic Guanosine Monophosphate. *ChemSystemsChem* 5, e20230001. <u>doi.org/10.1002/syst.202300016</u>

- Pokorný R., Vernerová M., Kloužek J., Cincibusová P., Kohoutková M., Pezl R., Ferkl P., Hrma P., Podor R., Schuller S., Kruger A. (2023): Transient Melt Formation and its Effect on Conversion Phenomena during Nuclear Waste Vitrification – HT-ESEM Analysis. *Journal of the American Ceramic Society* 1–15. <u>doi.org/10.1111/jace.19361</u>

- Ferkl P., Hrma P., Kloužek J., Kruger A., Pokorný R. (2023): Cold-cap structure in a

slurry-fed electric melter. *International Journal of Applied Glass Science* 15, 73–87. doi.org/10.1111/ijag.16645

- Kunc J., Kloužek J., Vernerová M., Cincibusová P., Ferkl P., Hall M., Eaton W., Hrma P., Guillen D., Kruger A., Pokorný R. (2023): Effect of feed composition on the production of offgases during vitrification of simulated low-activity nuclear waste. *Progress in Nuclear Energy* 166, 104932. <u>doi.org/10.1016/j.pnucene.2023.104932</u>

- Cihlář J., Navarro L.K.T., Cihlář J., Kašpárek V., Michalická J., Částková K., Lazar I., Kastyl J., Celko L., Veselý M., Dzik P. (2023): Influence of substituted acetic acids on "bridge" synthesis of highly photocatalytic active heterophase TiO2 in hydrogen production. Journal of Sol-Gel Science and Technology 105, 471–488. doi.org/10.1007/s10971-022-06011-8

- Hanzlíček T., Perná I., Michoinová D., Rafl J. (2023): The characterization and renovation of parterre floor tiles in the pilgrimage church of St. John of Nepomuk (Czech Republic). *Case Studies in Construction Materials* 19, e02297 doi.org/10.1016/j.cscm.2023.e02297

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All scientific departments popularised the results of their activities, either in exhibitions, in the framework of the Week of Science of the CAS or in field panels or presentations to the public (see section 7).

3. Research projects conducted by the Institute's scientific departments in 2023

Projects funded by the Czech Science Foundation (GACR)

- Landslides in a changing climate: temperature controls over landslide susceptibility and hazard in temperate climate, Period: 2024 2026
- Fossil seagrass meadows a neglected Phanerozoic ecosystem: its contribution to shelf biodiversity and identification in the fossil record, Period: 2023 2026

- Tree-ring microscopic anatomy as a chronological data source for optimization of landslide hazard assessment, Period: 2022 2024
- Coseismic landslides in the mountains of active and stabilized accretion wedges, Period: 2022 2024
- Study of methods for modification of mechanical properties and structire of collagen matter, Period: 2021 2023
- Mechanics of arterial delamination and crack propagation, Period: 2020 2023
- The role of rock anisotropy in hydraulic fracturing through acoustic emission, Period: 2022 2024

Projects funded by the Technology Agency of the Czech Republic:

- Natural seismicity as a prospecting and monitoring tool for geothermal energy extraction, Period: 2021 2024
- Rock Environment and Natural Resources, Period: 2022 2024

Projects Strategy AV21:

- Creating new materials using geopolymer technology to conserve and restore. Research Programme: City as a Laboratory of Change: Historical Heritage and Place for Safe and Quality Life, Period: 2020 – 2024
- Dynamic Planet Earth. Research Programme: Top research in the public interest, Period: 2023 2027
- Circular economy for the energy industry. Research Programme: Sustainable Energy, Period: 2022-2026

<u>Projects financed by the Ministry of Education, Youth and Sports and the Ministry of Health:</u>

- Experimental and mathematical analysis of primary glass-forming melt properties, gas evolution, and their relation with primary foam production. Research Programme: Inter-Excellence II USA ID: LUAUS23062, Period: 2023–2026.
- Biomechanically defined absorbable materials for cardiovascular surgery, Applied Health Research Support Programme ID: NU20-02-00368, Period: 2020–2023

Projects with foreign participation:

- Representation of the Czech Republic in the management of INQUA (International Union for Quaternary Research).
- The six-component continuous monitoring of seismic swarms and other earthquakes in the Long Valley Caldera area, California.

International projects:

- see section VI. International cooperation, p. 32.

4. Cooperation with universities

With respect to university teaching activities during the year, the staff of the IRSM provided in the summer semester 297 hours in bachelor's and 204 hours in master's study programmes; in the winter semester 263 hours in bachelor's, 204 hours in master's study programmes. The institute trained 12 doctoral students, 2 of them from abroad. The staff of the Institute worked as teachers and taught several courses and number of study programmes in various fields during the year, especially at the Charles University (Faculty of Science, Faculty of Mathematics and Physics and the Faculty of Medicine in Pilsen), the Czech Technical University in Prague (Faculty of Mechanical Engineering and the Faculty of Nuclear Sciences and Physical Engineering), the University of Chemical Technology (Faculty of Chemical Technology and Faculty of Environmental Technology), the Masaryk University in Brno (Faculty of Natural Sciences) and the University of South Bohemia in České Budějovice (Faculty of Education), as well as at the Universidad Nacional de Cordóba Argentina - Faculdad de Ciencias Exactas, Físicas y Naturales.

The Institute has two joint workplaces with universities, namely with the Faculty of Science of Charles University and the University of Chemical Technology in Prague.

The Institute's staff participated during the year in 5 doctoral study boards, namely at the University of Chemical Technology in Prague, the Technical University of Ostrava and Charles University in Prague (Faculty of Science).

The implementation continues of the "Agreement on Mutual Cooperation concerning the Implementation of the Physics of the Earth and Planets doctoral study programme" concluded with the Faculty of Mathematics and Physics of Charles University involving both full-time and combined forms of study.

5. Contractual services

Contracts:

1) Commissioned by: The Road and Motorway Directorate (ŘSD ČR)

Contract: Analysis of planned sections of motorways and class I roads and their potential risk of slope deformation 2023. Phase I.: Mapping and field verification of landslides in the locations of the planned constructions and their surroundings.

Summary: An analysis of the planned sections of motorways and class I. roads has been carried out in terms of their potential threat from slope deformations. The analysis evaluates the occurrence and extent of identified slope deformations along the route of the planned sections of motorways and class I. roads and comments on the potential threat to the planned structures from these deformations.

Application: Roads and motorways construction

2) Commissioned by: The Road and Motorway Directorate (ŘSD ČR)

Contract: Consulting activities of the Institute representative in the Monitoring Council of the D48 Motorway Bělotín - Rybí (RAMO).

Summary: Dr. Stemberk, representative of IRSM, participated in regular meetings of the Monitoring Council (RAMO) of the D48 Bělotín - Rybí motorway, which deals with the issue of slope stability and safety of the motorway. He was involved in the solution of the above mentioned problem through consulting activities.

Application: Road and motorway safety

3) Commissioned by: The Czech Radioactive Waste Repository Authority (SÚRAO)

Contract: Activity monitoring of the brittle structures of the Bukov URF and the Rožná mines - final evaluation and numerical model.

Summary: The obtained results are part of the tests of the behaviour of the rock environment at the assumed depth of the future underground repository.

Application: Deep disposal of radioactive waste.

4) Commissioned by: Energoprůzkum Praha, spol. s r. o.

Contract: Monitoring of movement activity at two selected dislocations in the Skalka mine adit in 2022.

Summary: The results of the monitoring describes the activity of faults, fractures and fissures in the Skalka mine locality for the needs of Energopruzkum.

Application: The Power engineering and energy advisory.

5) Commissioned by: Vyšehrad National Cultural Monument management Contract: Stability monitoring of selected objects in the Vyšehrad National Cultural Monument. Summary: The stability of the selected objects of the Vyšehrad National Monument for the needs of its administration has been monitored and evaluated.

Application: Preservation of Monuments

6) Commissioned by: Adršpach Technical Services, s.r.o.

Expertise: Stability assessment of the rock blocks above the western side of the lake in the The Adršpach-Teplice rock town.

Summary: As part of the management of the Adršpach Rock Town, the stability of the rock wall was monitored and assessed with regard to the possibility of rockfall and the safety of tourist traffic during tours of the rock towers.

Application: Ardšpach Rock Town care

Expertise:

1) Commissioned by: GasNet Služby, Ltd., Brno – Zábrdovice

Expertise: Geophysical survey of the bedrock using multi-electrode resistivity method and shallow refraction seismic method on the left bank of the Vltava River above the railway line 090 for the construction of the REKO VTL DN 150 ŘEŽ U PRAHY. Report on geophysical survey and Final report on the combined geophysical survey of bedrock by multi-electrode resistivity method and shallow refraction seismic method (MRS) for the construction of "REKO VTL DN 150 Řež u Prahy" on the left bank of the Vltava River above the railway line 090 Prague - Kralupy nad Vltavou - Děčín in the locality of Řež u Prahy.

6. International cooperation

The Institute participated during the year in 5 international projects, in 13 bilateral scientific cooperation agreements with foreign partners and cooperated with an International Advisory Board. The Institute's staff participated in 8 international scientific organizations, in two cases in official management positions.

International projects:

1) Mathematical Modeling and Experimental Evaluation of Melter Cold Cap for Nuclear Waste Vitrification. Battelle Energy Alliance, LLC, Idaho, USA, Contract No. 166789, 2016–2026.

2) International project GACR/MOST TW 22-24206J Earthquake-triggered landslides in recently-active and stabilized accretionary wedges, 2022–2024.

3) Radiolytical alteration of the organic matter in coal and rocks enriched in radioactive minerals. International Committee for Coal and Organic Petrology, 2023.

4) Natural Seismicity as a Prospecting and Monitoring Tool for Geothermal Energy Extraction. Iceland, Liechtenstein and Norway grants (the EEA Grants) and the Technology Agency of the Czech Republic, 2021–2024.

5) European initiative Adria Array: Understanding Active Deformation of the Adriatic Plate and its Margins, 2023.

Official positions in the membership of international organisations:

- 1) Doc. Ing. Jaroslav Kloužek, CSc.: International Commission on Glass, Technical Committee No. 18 Glass melting. Vice president, term of office: 2019 2025.
- 2) RNDr. Petra Štěpančíková, Ph.D: International Union for Quaternary Research, Commission on Terrestrial Processes, Deposits, and History. Vice president, term of office: 2023 – 2027.

Bilateral cooperation with foreign partners:

1) Instituto Geofísico del Peru

Theme: The monitoring and assessment of landslide hazards in selected locations in Peru.

2) Instituto Nacional de Investigación en Glaciares y Ecosistemas de las Montaña (Peru) Theme: The evaluation of the danger of slope movements around the village of Rampac Grande, Cordillera Negra, Peru.

3) Instytut Geofizyki Polskiej Akademii Nauk

Theme: The research of tectonic movements and slope deformations in the Svalbard archipelago.

4) Uniwersytet Wroclawski

Theme: The research of the structural-geological conditions and construction of the Broumov/ Góry Stolowe table mountains; arctic and permafrost research.

5) Naturhistorisches Museum Wien

Theme: The research of active tectonics in caves in the Eastern Alps.

6) Johannes-Guttenberg Universität Mainz Theme: The radiometric dating of active tectonics in karst caves.

7) University of Memphis

Theme: The research of local seismicity.

8) Uniwersytet Wroclawski – Wydzial Nauk o Ziemi i Ksztaltowania Srodowiska Agreement of co-operation: Joint research projects concerning research fields stated in the agreement; Exchange of academic staff and students; Joint publications and exchange of scientific and didactic materials; Organisation of joint scientific conferences and workshops.

9) Polish Geological Survey Theme: Monitoring of tectonic movements in Niedzwiedz Cave.

10) INGEMMET – Instituto Geológico, Minero y Metalúrgico Theme: The monitoring and assessment of landslide hazards in selected locations in Peru

11) Chelungpu Fault Park (Zhushan), NCU (Tayouan), Taiwan Theme: 3D measurements of micro kinematics at Chelungpu seismic fault.

12) Agency of Rural Development and Soil and Water Conservation, MOA – m ARDSWC (Nantou), Taiwan Theme: Monitoring of deep landslides triggered by extreme rainfall. 13) Université Savoie Mont Blanc, ISTerre (Le Bourget du Lac).Theme:Monitoring of deep alpine structurally conditioned potentially catastrophic landslides in the Chamonix area.

International Advisory Board of the IRSM (IAB)

In 2023, the members of the International Advisory Board were informed about the research activities of each departments. The members of the Board provided recommendations for further improvements activities of the IRSM.

Chairman

Dr. Rouwen Lehné
Hessisches Landesamt f
 ür Umwelt und Geologie (HLNUG)
Dezernat G1 – Geologische Grundlagen, Rheingaustr. 186, 65203 Wiesbaden, Germany

Members:

- **Prof. Vladimir Yudin** Institute of Macromolecular Compounds RAS 199004 Saint-Petersburg, Bolshoy pr. 31, Russia

- Prof. Dr. Manfred Joswig

Stuttgart University, Institut für Geophysik Goethestr. 25, D-40237 Düsseldorf, Germany

- Dr. Yann Klinger

Institut de Physique du Globe – CNRS Université de Paris 1, rue Jussieu 75238 Paris cedex 05, France

- Prof. Dr. Kimon Christanis

University of Patras, Department of Geology University Campus, GR-265.04 Rio-Patras, Greece

7. Popularisation and public education activities

1) Excursion in the Laboratory of Environmental Technologies focused on instrumental analysis methods and possibilities of analytical determinations for the company TEDOM, Jablonec nad Nisou and Hořovice, 12 January, 7 February and 9 March 2023.

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2) Excursion in the Laboratory of Environmental Technologies focused on the technological processing of organic waste. Presentation of the laboratory and its activities for LOGeco Ltd.,
17 January 2023 and 2 February 2023

3) Presentation of methods of the Laboratory of Environmental Technologies. Demonstration of equipment for the analysis of gases, oils and solid carbonaceous products for the company I&AAT Ltd., 22 February 2023.

4) Presentation of apparatus and analytical methods of the Laboratory of Environmental Technologies to the representatives of VWR International company for the purpose of establishing cooperation, 26 April 2023.

5) Presentation of technological equipment of the Laboratory of Environmental Technologies: tour, tour, description of the functions of the equipment and consultation with the Director of the Decarbonization Department Ing. Martin Růžička, ORLEN Unipetrol, RPA s.r.o., Litvínov, for further cooperation. Institute of Chemical Engineering of the CAS, Prague, 2 May 2023

6) A tour of the institute's facilities and a consultation with the manager Ing. Martin Srb -Prague Water Supply and Sewerage company, the Water Technology Unit and Dr. Nisler and Dr. Forczek - Institute of Experimental Botany of the CAS, for further cooperation, 10 August 2023.

7) Presentation of laboratories and their activities for the contract of thermal treatment of glass fibre in the framework of cooperation with the University of West Bohemia in Pilsen and the industrial organisation ACO Tábor, 13 and 21 September 2023.

8) The Week of the Czech Academy of Sciences: Presentation of the geochemistry laboratory (illustration of pores and adsorption mechanisms on a macro scale, microscope window, colour experiments, rocks and sorption materials, demonstration of the transformation "from plant to coal"), geopolymers laboratory and thermal processes laboratory (possibilities of treatment/use of inorganic and organic waste), laboratory composite materials (demonstration of the production of polymer nanofibres by electrostatic softening), seismometer and drone demonstration, 8 - 9 November 2023.

9) Science Fair 2023: Presentation of the activities of the Department of Neotectonics and Thermochronology: tectonic movements and earthquakes, seismic hazard assessment, rock dating, landscape evolution and morphostructural analysis of georelief, long-term evolution of slope deformation. Presentation of the activities of the Department of Composite and Carbon Materials: function and structure of collagen, its role in connective tissues and in the development of biomaterials, demonstration of isolation and preparation of collagen cell carriers and nanofibers. PVA - EXPO Praha Letňany, 8 – 10 Jun 2023.

10) Seminar Biomaterials and their surfaces: basic issues of biomaterials and the current state of research and development and production of prosthetics or artificial replacements in the Czech Republic. Department of Composite and Carbon Materials, Herbertov Southern Bohemia 19 – 22 September 2023.

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8. Network monitoring

<u>Monitoring 1</u> Monitoring network: SlopeNet: Monitoring of slope deformations, landslides and rock falls. Operator: IRSM, RENS Programme. Activities: The geophysical and geotechnical monitoring of slope defo

Activities: The geophysical and geotechnical monitoring of slope deformations with corresponsibility for monitoring.

Monitoring 2 Monitoring network: Network EU TecNet: The 3D monitoring of tectonic structures in the EU. Operator: IRSM, Czech/Geo Programme. Activities: Device readings, service and data evaluation.

<u>Monitoring 3</u> Monitoring network: Czech Regional Seismic Network: Earthquake monitoring in Europe and worldwide. Operators: Institute of Geophysics AS CR, IRSM, Institute of Geonics AS CR, Institute of Earth Physics, Masaryk university and the Charles University Faculty of Mathematics and Physics, Czech/Geo Programme.

Activities: Basic scientific earthquake research infrastructure, especially concerning long-term seismicity research in Europe and worldwide.

Monitoring 4

Monitoring network: MKNET:

Earthquake monitoring in the Lesser Carpathians.

Operators: IRSM, the Earth Science Institute of the Slovak Academy of Sciences, Progseis Ltd., Czech/Geo Programme.

Activities: the continuous recording and evaluation of detailed research data on selected seismically active areas.

Monitoring 5

Monitoring network: REYKJANET: The monitoring of earthquakes in Iceland. Operators: Institute of Geophysics AS CR and IRSM, Czech/Geo programme Activities: Detailed long-term international research in a seismically active area of Iceland.

Monitoring 6

Monitoring network: Landslides, rockfalls and ground currents as recorded in the media since 2011: The emergence and reactivation of slope deformations in the Czech Republic. Operator: IRSM, NASA Programme.

Activities: Determination of the location and the time of occurrence of landslides, and the damage they cause.

Monitoring 7

Monitoring network: TecNet:

The monitoring of slow movements along tectonic faults.

Operator: IRSM, Czech/Geo Programme.

Activities: The tracking of seismic tectonic movements along faults.

9. Published periodicals

 Acta Geodynamica et Geomaterialia, Vol. 20, Nos. 1 - 4, 2023, ISSN 1214-9705 (Print); ISSN 2336-4351 (Online), is an international multidisciplinary journal focusing on research, applied science, and education in geophysics, geodynamics, geology, geodesy, petrography of geomaterials, materials engineering and mineral raw materials processing. Impact-factor journal published on a quarterly basis. Database monitoring: Science Citation Index Expanded; Journal Citation Reports/Science Edition.

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 Ceramics-Silicates, Vol. 66, Nos. 1–4, 2022, ISSN 0862-5468 (Print); ISSN 1804-5847 (On-line). Impact-factor journal published on a quarterly basis. Database monitoring: Science Citation Index; Materials Science Citation Index; the Engineering Index (Published by Engineering Information Inc.).

IV. Evaluation of other activities

The Institute has no other activities. For the evaluation of other activities, see Section III, point 5.

V. Information on measures to remedy management deficiencies and the report on how the said measures imposed in the previous year have been implemented

The IRSM had no management deficiencies in 2023 or in the previous year.

VI. Financial information on items that are significant in terms of the assessment of the economic situation of the Institute that may affect its future development

See the financial statement - Profit and loss statement 2023.

VII. Envisaged development of the Institute's activities

The scientific activities of the IRSM will continue to develop in accordance with global research trends, with an emphasis on publishing and teaching and popularisation activities. With respect to scientific research and the enhancement thereof, the Institute will continue to recruit from the doctoral study programmes mentioned previously in this report. The certification of the Institute's researchers will continue aimed at enhancing the quality of their work. The performance of researchers will be rewarded by increases in remuneration and the adjustment of working hours. The Institute's equipment will be expanded, updated and developed on a continuous basis and the staff will be provided with the appropriate training.

VIII. Environmental protection activities

In response to the needs of society as a whole, the assessment of alternative fuels will continue and the Institute will continue to be involved in developing plastic and municipal waste treatment methods, the treatment and transformation of sludge from wastewater treatment plants into fertilisers and the advancement of radioactive waste disposal technologies. A further significant contribution comprises the development of a municipal waste processing method in cooperation with two industrial companies. Conditions are in place for IRSM employees to recycle their waste and hazardous waste is disposed of ecologically by authorised companies. Pest control is performed on a yearly basis.

Institute of Rock Structure and Mechanics of the CAS, V Holešovičkách 94/41, 182 09 Prague 8, Czech republic Profit and loss statement											
ID nu 67985	mber 5891	According to Decree No. 504/2002 Coll.									
		Activities									
Number	Designat	esignation Main activity Suppleme		Supplementary	Total						
A	A. Expen	1565		-	activy						
A.I	I. Cons	umed purchases and purchased services	002	20 322	1 648	21 970					
A.I.1	1.Cons	umption of material, energy and other non-inventory items	003	6 364	646	7 010					
A.I.3	3. Repa	airs and maintenance	005	4 628	0	4 628					
A.I.4	4. Trav	el expenses	006	1 498	573	2072					
A.I.5	5. Repr	resentation costs	007	48	4	52					
A.I.6	6. Othe	er services	008	7784	424	8 208					
A.III	III. Tota	al personnel expenses	013	66 539	984	67 523					
A.III.10	10. Wa	ges and salaries	014	48 717	730	49 446					
A.III.11	11. Sta	tutory social insurance	015	16 243	240	16 482					
A.III.13	13. Sta	tutory social expenses	017	1 580	14	1 594					
A.IV	IV. Tota	al taxes and fees	019	612	3	615					
A.IV.15	15. Ta	xes and fees	020	612	3	615					
A.V	V. Total	l other expenses	021	2 554	1 022	3 576					
A.IV.17	17. Bac	d debts write-off	023	4		4					
A.V.19	19. Exc	change rate losses	025	80	0	80					
A.V.22	22. Oth	ner expenses	028	2 470	1 022	3 492					
A.VI	VI. Tota utilizatio	. Total depreciation expenses, sold assets, addition and lization to reserves and adjustments		12 447		12 447					
A.VI.23	23. Dej	preciation expenses of fixed assets	030	15 068	0	15 068					
A.VI.27	27. Addition and utilization to reserves and adjustments		034	-2 621	0	-2 621					
A.VIII	VIII. To	otal income tax	037	17	0	17					
A.VIII.29	29. Inc	ome tax	038	17	0	17					
	Total exp	penses	039	102 491	3 657	106 148					
В	B. Reven	nues									
B.I	I. Total	operating grants	041	83 184	0	83 184					
B.I.1	1. Oper	rating grants	042	83 184	0	83 184					
B.III	III. Rev	enues of own services and merchandise	047	146	4 159	4 306					
B.IV	IV. Tota	al other revenues	048	19 672	0	19 672					
B.IV.7	7. Inter	rest income	051	490	0	490					
B.IV.8	8. Exchange rate gains		052	16	0	16					
B.IV.9	9. Settl	ement of funds	053	1 295	0	1 295					
B.IV.10	10. Oth	ner revenues	054	17 872	0	17 872					
	Total rev	venues	061	103 003	4 159	107 162					
С	C. Profit	t / Loss before tax	062	529	503	1 031					
D	D. Profit	t / Loss after tax	063	512	503	1 014					

IX. Further sections of the Annual Report: Profit and loss statement 2023



Institute of Rock Structure and Mechanics of the Czech Academy of Sciences V Holešovičkách 94/41 182 09, Prague 8 Czech Republic

> Phone No.: +420 266 009 318 E-mail: <u>irsm@irsm.cas.cz</u> VAT: CZ67985891 <u>www.irsm.cas.cz</u>